JOURNAL of the
SOCIETY of MOTION PICTURE and TELEVISION ENGINEERS

In This Issue

THIS ISSUE IN TWO PARTS
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MAY 1950

Announcing:

68th Semiannual Convention

For the first time since the War, your Board of Governors has decided to hold a semiannual convention away from a big city: the 68th Convention will be at the Lake Placid Club, in the heart of the Adirondacks, — a restful private club, where you can relax, and at the same time derive maximum value from the many excellent technical papers to be presented. Older members of the Society will remember with pleasure our former meetings in these delightful surroundings; so prepare now to be present, and remember the dates: October 16 through 20.

Watch for the detailed information which will appear in a later *Journal,* and then act promptly to make your plans and reservations.

E. I. Sponable
President

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Progress Committee Report

MUCH OF THE PROGRESS in the motion picture studios during 1949 is traceable to a determination for greater economy in production without altering the box-office drawing power of the product. Some of the techniques and equipment which have been received primarily on an economy basis would have been accepted on any other basis because of their apparent value; others have found limited use as a perusal of this report will show. A résumé of the articles and papers listed in the references indicates that, while some care has been taken that the new techniques do not reduce box office value, they have had considerable influence on the type of productions made.[1-4]

A number of the points of progress in the era of the economy move are so simple as to have been overlooked when total picture cost was not such an alarming factor. An example is the movement of horses to western picture locations where a second cab has been placed on the prime mover of the truck-trailer combination to accommodate the wranglers who formerly used a separate automobile to follow the truck.

Progress in picture and sound reproduction is highlighted by successful efforts to provide more screen light for large indoor and drive-in theaters.

In the television field there is a distinct movement toward the application of motion picture studio techniques as a transitory stage leading toward the perfection of television techniques as such. Whereas in the past television has been restricted to a large extent by the space limitations of the radio broadcasting studio it is now expanding to the motion picture studio types of buildings where it is possible to have permanent sets and to utilize many of the process tricks of motion picture production which help to provide realism.

35-Mm Photography

Progress in the fields of motion picture film, cameras, and studio lighting is again largely a consolidation of the use of techniques and equipment previously announced.

Documentary style pictures which make use of natural locations and low-key effect lighting came as a part of a shift in production techniques. Color has gone to the locale of the story and the motion

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picture trade journals report American color productions in Utah, Arizona, England, Italy, Belgian Congo, India and Africa. Production in the West Coast studios has been sporadic.

Preplanning of the motion picture has gained some headway. In Great Britain the "Independent Frame" technique, whereby the picture is preplanned frame by frame, has created considerable interest and has resulted in some pictures being made under that system.[5] Production in the United States is moving toward preplanning on the basis of evolution, rather than revolution, in order to avoid loss of spontaneity and emotional effect in the finished product.

Considerable additional use has been made of the latensification process as a means of reducing the cost of producing motion pictures.[6,7] It is claimed that since latensification permits lower levels of light intensity, the over-all production can be conducted at a faster pace. The latensification and resulting development processes produce an increase in graininess of the film. Under certain conditions improved photographic quality is claimed for the latensification process in that it enables the exposures to be made using smaller camera stops than would otherwise be the case.

In the United States the low shrinkage safety base film of the triacetate type, introduced by Eastman Kodak Co., has been received with considerable favor. It is currently being used for release prints and studio work prints.[8] There has been some application as a sound recording negative and experiments are in progress to determine its adaptability to picture negative films. While the prime purpose of the use of safety film is to decrease operating hazards, the economies effected by its use are of considerable magnitude, from reduced building costs and simpler equipment to lower insurance charges and transportation.

A Signal Corps project with Armour Research Foundation of Illinois Institute of Technology is in its second year covering development of film bases suitable for use over a wide temperature and climate range. Several apparently satisfactory materials have been found and are being developed.

Another project by the same group is directed toward evaluating the fundamental factors pertaining to the use of diazo compounds for the preparation of photographic films with speed and range. The objective of this program is a new high-speed processing that will yield direct positives with a simple one-step development procedure.

The Interagency Advisory Committee for Nitrate Film Vault

Tests has continued its work during 1949.[8a] Tests conducted by the National Archives and Record Service, co-operating with the National Bureau of Standards and the motion picture industry, have led to definite conclusions. Results of the 1948 tests led to the preparation of specifications and the manufacture of improved film storage racks of both open and closed types. Thorough tests of the new racks, with various types of water sprinkler systems, and tests with no water, have shown that the rack design is highly successful in holding the film loss to a negligible degree. This is especially true with the closed rack design. The tests also indicated that smoke detection equipment was of little value in preventing loss. Other tests conducted by this committee on the decomposition of nitrate film have shown that nitrate film in the third and fourth stages of decomposition will spontaneously ignite at temperatures as low as 120 F.

The Photo Research Corp. and the W. M. Welch Manufacturing Co. have announced photoelectric densitometers of interest. The former is intended for color use by means of filters. The Welch Densichron is notable for its accuracy and stability as a result of a-c field modulation of the cell.

Color Processes

The Ansco process has been further developed and has received additional commercial use. A complete line of film types is now available for all of the necessary steps from original taking film through the duping and special effects steps to release prints.

Du Pont has introduced a positive film for making three-color prints from separation negatives.[9,10] This film is notable in that it employs a synthetic polymer which combines the functions of the gelatine and the color formerly usually employed. There has been little if any commercial use of this film.

Eastman has introduced, on an experimental basis only, a 35-mm negative-positive color process. This involves a camera negative film which yields a complementary color negative, with integral color masks, which is printed onto a color print film yielding a positive color print. The color print film may also be used with separation negatives. The color forming couplers are incorporated into the print film.

Both Eastman and Du Pont have been experimenting with a negative film which involves the use of three emulsions, two of which are

subsequently stripped from the original base and mounted on new film bases in the laboratory before development. Although various problems connected with this process are not completely solved, both companies successfully performed the operation on considerable quantities of film. There are no known commercial uses of the process.[11]

A three-color printing method was described for the Cinecolor process.[12]

Lighting Equipment and Techniques

Carbon Arcs. Carbon trims for the MR "Brute" lamp which operates at 225 amp have been modified to reduce noise level both at striking and during burning periods.[13]

Incandescent Bulbs. The reflector type of incandescent lamp, of which the photoflood and photospot are examples, has found added use particularly on documentary type and other pictures where low-level effect lighting is indicated.

Mercury-Cadmium Lamps. The mercury-cadmium lamp, called the compact source lamp in England where it was first developed, has been slow in achieving acceptance by the British motion picture industry. It is now being used, to a limited degree however, for both black-and-white and color photography. Lamps are available at 2½ and 5-kw ratings with a few 10-kw lamps available on an experimental basis.

Samples of 5-kw mercury-cadmium lamps, operating at approximately 70 amp at 70 arc volts, have been delivered by American manufacturers to interested companies in Hollywood.[14-16]

Cameras and Accessories

A new portable camera, called Camerette, manufactured by Etablissements Cinematographiques Eclair of France, was introduced in Great Britain and Europe in 1948 and in the United States in 1949. Coupled with the light weight of the camera, its instantaneously interchangeable magazines and reflex viewing, is a double pull-down movement with an ingenious system of pressure pads and spring guides to insure steady operation.[17]

A new electronic shutter analyzer employing a two-gun cathode-ray oscilloscope with two phototubes has been developed by the Navy.[18] This device is designed to permit the rapid analysis and solution of numerous problems commonly encountered in photography including: analysis of motion picture camera shutters; cali-

bration of frame-per-second tachometers; shutter-flash synchronization; diaphragm calibration; duration and intensity of light emitted by flash bulbs and some gaseous discharge tubes.

Set Construction

Translucent Photographic Backings. Perhaps one of the most interesting developments is a new photographic backing introduced by M. P. Paul of Hollywood. This backing is available in fairly large sizes, either black-and-white or in full color. It is translucent and permits novel and realistic effects to be obtained by lighting from the back. Single photographic enlargements on seamless, translucent sheets are produced in sizes up to 20 × 45 ft.[19,20]

A number of studios are making more and better use of steel scaffolding as an underpinning for elevated sets. It is claimed that savings as high as 80% are possible over the wood type of semipermanent construction.

Scotchlight, a highly reflective material, is sometimes used in windows and doors to indicate that light is coming through from outside, or from another room in the case of doors.

There was considerable activity in the application of new plastic materials to the various phases of set construction. These include breakaway glass, combinations of plaster and plastic, low-temperature thermosetting plastics for casting ornamental objects of various types, lightweight tree trunks, building columns, sections of trains and many other similar applications (Fig. 1).

There has been developed and is in regular use in most of the Hollywood studios, a strippable adhesive for use with wallpaper and temporary flooring such as linoleum or asphalt tile. In both applications, this adhesive affords the easy removal of the surface material after its use.[21]

16-MM AND 8-MM PHOTOGRAPHY

Papers and reports on high-speed photography have completely filled two issues of the JOURNAL during 1949 providing an excellent reference work for the subject.

Advance in the employment of high-speed photography in the Army, Navy and Air Force during 1949 was notable. This was not so much in the improvement in equipment as in the expansion of the applications, techniques and fields of usage of high-speed photog-

Fig. 1. Plastic and wood locomotive used by 20th Century-Fox for their picture "A Ticket to Tomahawk."

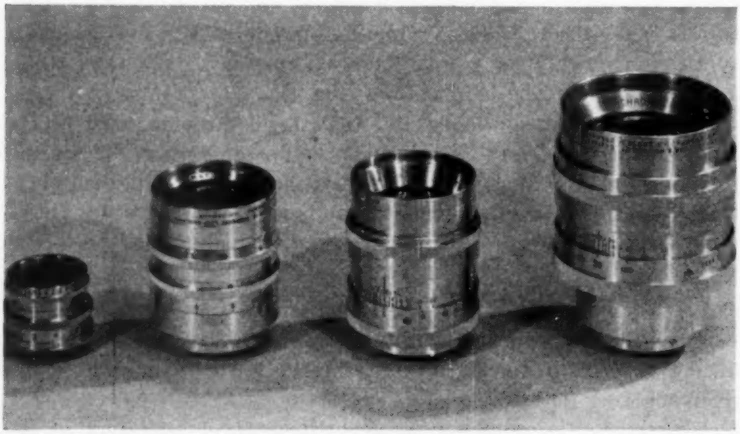

Fig. 2. Series of coated lenses, from left to right: .7-in. T2.7 ($f/2.5$) Bell & Howell Super Comat; 2-in. T1.6 ($f/1.4$) Taylor Hobson Cooke Ivotal; 2.8-in. T2.5 ($f/2.3$) Taylor Hobson Cooke Panchrotal; and 4-in. T2.5 ($f/2.3$) Taylor Hobson Cooke Panchrotal.

raphy. In research, development and testing of new weapons and equipment, high-speed photography has proven a valuable tool.

Extensive ballistic data on long-range and guided missiles in the Army Ordnance Department's missile program at White Sands Proving Ground are obtained with the extensive use of motion pictures.[22] Tracking telescopes have been developed which are in effect motion picture cameras of very long focal lengths. Telescopes up to 16-in. size, and focal lengths up to 80 ft have been used. Stationed 40 miles from the launching site at an elevation of 8,000 ft, these instruments have photographed V-2 missiles and furnished their trajectories to an altitude of approximately 35 miles. Orientation of the axis of a V-2 missile at an altitude of 20 miles has been determined with a probable error of 0.6 deg.

A pressurized ballistics range has been installed at the Naval Ordnance Laboratory which will permit the study of aerodynamic characteristics of missiles at different Reynolds numbers, and will lead to a better correlation between small models and full-scale data. The range is located in a steel tube, 3 ft in diameter and over 300 ft long. Pressure up to five atmospheres and down to one-hundredth of an atmosphere can be obtained. Twenty-five photographic stations are located along the tube to photograph the missile by the direct shadowgraph method using high-speed flash actuated by the missile as it passes between a source of light and a photocell. An electronic chronograph measures the time intervals between stations.[23]

During the past year a number of 16-mm and 8-mm cameras and projectors intended for the amateur trade were introduced by various manufacturers. Of particular interest to the professional trade were a new Bell & Howell Design 2709 16-mm camera. This resembles the standard 35-mm Bell & Howell camera with the Unit I shuttle. The Nord Co. announced a professional camera, and Pathé Cine, a division of Director Products, Inc., announced a new Pathé Super 16 Camera.

A new view finder, announced by the French Emel Co., covers a field ratio from 1 to 8, whereas the finder image remains 33 × 44 mm regardless of the change in field.

Bell & Howell has announced a new series of coated lenses for 16-mm cameras developed in co-operation with Taylor Hobson, England (Fig. 2). These lenses are supplied with click stops. The focal lengths of the series are chosen to provide uniform magnification

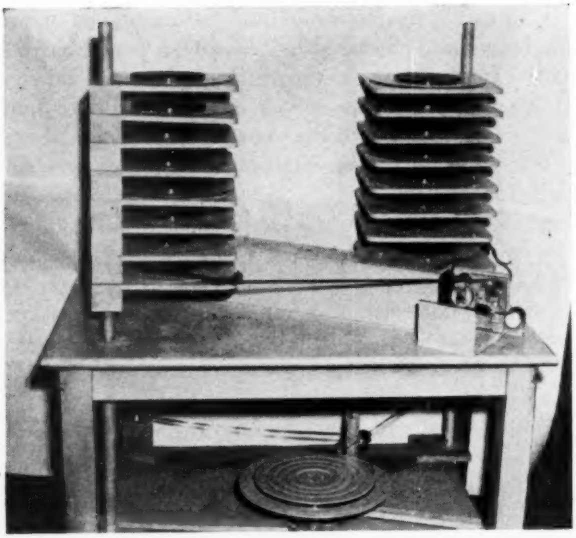

Fig. 3. Multiple duplicator for contact printing magnetic recordings.

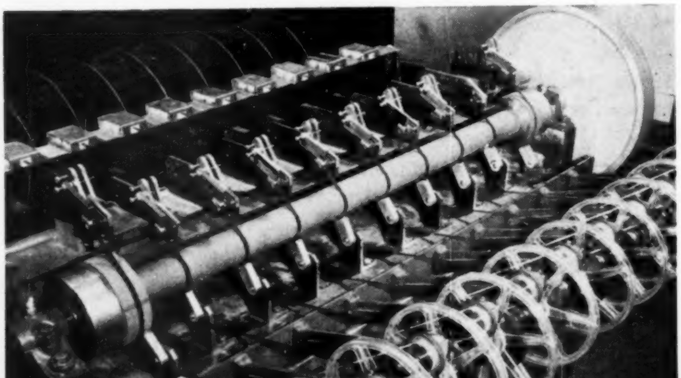

Fig. 4. Multiple track magnetic tape duplicating machine.

steps. Of particular importance is the improvement of corner resolution in the new series.

Western Electric and Wollensak have announced a new objective series and finder improvements for the Fastax high-speed cameras.

35-Mm Sound Recording

Magnetic recording is gradually being integrated into the production of motion pictures in England, Europe and the United States. Its freedom from photographic and developing distortions, the possibility for somewhat smaller and lighter recording equipment, and operating economies are the factors stimulating its use.

A number of new magnetic recording and reproducing devices were introduced, such as the modification of theater-type soundheads for magnetic reproduction, and combination photographic and magnetic recorders and reproducers.[24] Westrex and RCA modifications were available to convert photographic recorders, soundheads, and film phonographs for both photographic and magnetic film.

Completion of a contact printing process for magnetic recordings was announced by Marvin Camras of Armour Research Foundation of Illinois Institute of Technology and one of its licensees, Minnesota Mining & Manufacturing Co. (Fig. 3). The method permits faithful duplication at high speed and in large quantities from pre-equalized master type. The master is held in contact with a blank tape while thé two are passed through a "transfer field." Upon separation of the copy tape from the master, it retains an accurate reproduction. The method is applicable to discs also.

An eight-tape single master tape printer will produce more than 960 hr of recording per day. Of particular interest is the economy of the magnetic printing process, as the master does not deteriorate during use. No further processing of the copy is required. The speed or "exposure" during printing is not critical.[25]

The Minnesota Mining & Manufacturing Co. announced a multiple track magnetic tape duplicator using conventional recording technique simultaneously on several tapes (Fig. 4).[26]

Warner Brothers Pathé News have made use of RCA's magnetic recording facilities to speed up the final preparation of newsreel material by the editing office, as well as to improve the sound quality of newsreel releases.

Paramount Studios have been using a magnetic sound recording channel for production shooting, the entire weight of which has been

reduced to under 150 lb. Utilization of magnetic recording is being expanded and within a year all production, scoring and dubbing recording will be on magnetic film. Photographic films will continue to be used for sound negatives and for release prints.

Columbia Studios soon expect to go into a method of re-recording in which multi-track 35-mm magnetic film will be used as the medium for storing various dubbing components, for later use in the dubbing of foreign versions, television versions, 16-mm versions and normal domestic release.

Dubbing consoles are being rewired so that the dubbing output is divided into four channels: a dialogue channel, a music channel, a sound effects channel and an over-all channel, including the normal dubbing output. The first three channels will feed the three tracks of a multi-track magnetic recorder. The last channel will feed a normal film recording channel.

When the dubbing is made, the first three channels will be used to store the result on a single 35-mm magnetic film. When a satisfactory take has been obtained it will be transferred to film from the magnetic tape, eliminating the recording of worthless takes.

The magnetic film will then be stored for the future dubbing of various versions which will be obtained by transferring the desired number of sound tracks from the magnetic film to photographic film.

This procedure will result in the elimination of worthless dubbing takes, reduction in the dubbing time and cost of foreign versions, and the improvement in quality of all dubbed versions. It will simplify the work of supplying the laboratory with identical duplicate negatives and will reduce storage space by a factor of 15 to 1 where the original dubbing material must be stored.

A new miniature condenser microphone and associated amplifier has been introduced in Hollywood by the Altec Lansing Corp.[27] It is a high-quality instrument and is nondirectional. Its application in the motion picture studios in Hollywood has thus far been limited to music recording.

The RCA MI-10001 microphone has been further improved by the addition of a fine mesh magnetic screen which is located in front of the ribbon and screens out foreign particles which are apt to become lodged in the air gap. This screen also reduces wind noise effects.

Among the items announced by Westrex Corp. during 1949 are:

(1) A precision motor speed control using a special duplex-type crystal as a reference to maintain a speed accuracy equivalent to

better than ⅔ of a frame in 500 ft.[28] Two or more of these units allow the sound recorder and camera(s) to be operated from completely independent power sources and yet obtain effectively synchronous performance.

(2) A variable-area modulator to be used in the Westrex portable recording system.[29] A new optical system making use of reflecting surfaced light valve ribbons enables the recording of direct positive as well as negative variable-area sound tracks.

35-MM PICTURE AND SOUND REPRODUCTION

The demand for increased light for large screen projection used in the major indoor and drive-in theaters has resulted in the announcement and application of new projectors, carbon arc lamp houses, faster optics and improved carbon trims.

The problem of film heat tolerance which was the bottleneck limiting the use of these advancements was given considerable attention on the basis of compressed air on the film, heat filters in the light beam of both absorption and reflection types, and water-cooled aperture units. Installations of equipment using these various means of cooling have been made in numerous locations and they are now being evaluated according to their respective merits.[30-33]

Improvements in projectors include opening of the systems for the faster $f/2.0$ and $f/1.9$ objective lenses and increased shutter transmission.

Improvements in carbon arc lamp houses include better auxiliary magnetic control of the arc flame, arc positioning devices, improved ventilation and, in the case of mirror type lamps, faster and more accurate mirrors.[34-36]

New objective lenses with speeds to $f/1.9$ in focal lengths from 5 to 7 in. have been placed on the market.

Carbon trims of higher intrinsic brilliancy for operation up to 180 amp and designed for the faster optics and greater heat tolerance are being introduced.[37]

The total improvements will allow for double the screen light of that formerly used in many cases.[38]

A portable device for measuring radiant energy at the projector aperture was described.[39]

Considerable work has been done by the Research Council, Inc., Eastman Kodak Co., National Carbon Division of Union Carbide & Carbon Corp. and others toward the dissemination of information

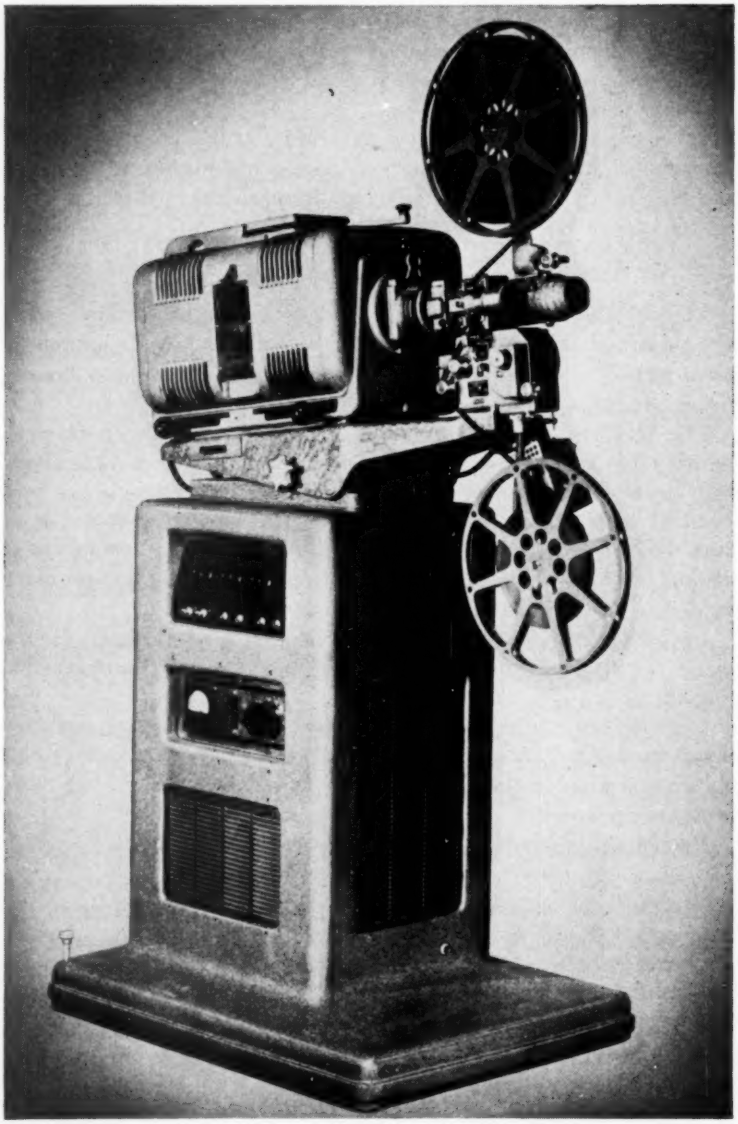

Fig. 5. Bell & Howell's Filmoarc Model 140 U with amplifier and rectifier completely housed in streamlined base. Connecting cables are concealed for smooth exterior appearance.

which will provide better co-ordination between set lighting, auditorium illumination and projection light.[40]

Projection optical train alignment devices have been placed on the market by a number of carbon arc lamp manufacturers.

Attention has been given to screen surfaces and nonperforated screens of cotton and fibre glass have been placed on the market. The makers claim greater reflectivity without distortion due to sound absorption.

A new light source developed by the Western Union Co. is an open arc between zirconium cored nickel electrodes. This arc has electrical characteristics and other features similar to the low-intensity carbon arc. Long electrode life is a stated advantage.

16-Mm Reproduction

In the field of 16-mm projection, the Bell & Howell 16-mm carbon arc has a reflector of rhodium, giving 1300 lumens output. The announcement of a solid pedestal base for the above is evidence of the increasingly professional use of such equipment (Fig. 5).

The incorporation of a removable 6-in. speaker into the side of the projector cabinet has permitted a weight reduction to 35½ lb for the Bell & Howell single case 185 projector. Bell & Howell also announced a new design of 2-in. $f/1.6$ Super Proval projection lens for all current 16-mm projectors. The lens resolves 100 lines/mm at the center, 80–90 at the side, and 40 at the corners. The design is a descendant of a Petzval incorporating a modified form of field flattener.

Except in special instances the Navy is producing no more official sound slide films for training purposes at the present time. The Filmagraph is being produced to take their place. In certain instances, it replaces regular motion pictures where motion is not an integral part of the teaching. The Filmagraph is a series of still pictures or art frames, either color or black-and-white, photographed on 16-mm film at 24 frames/sec. An appropriate sound track accompanies the picture, and it is projected on a regular 16-mm sound motion picture projector. The Filmagraph may include stock motion picture footage and simple art work. Its advantages are: (a) economy by standardization on one type of projection equipment, (b) elimination of synchronization difficulties often encountered with sound slide films, (c) better average projection conditions than for slide films, and (d) ease of handling and storage.

TELEVISION

Probably the most radical step in the changing scene in television production was the purchase of Vitagraph studio property in Hollywood by the American Broadcasting Co. These stages upon which some of the most famous motion picture stars performed before the cameras now give ABC Television Center facilities for operations comparatively unhindered in contrast to cramped quarters of the radio broadcast studio (Fig. 6). The site covers 23 acres and is said to contain the world's largest television sound stage. The facilities include process projection, permanent sets and some of the other

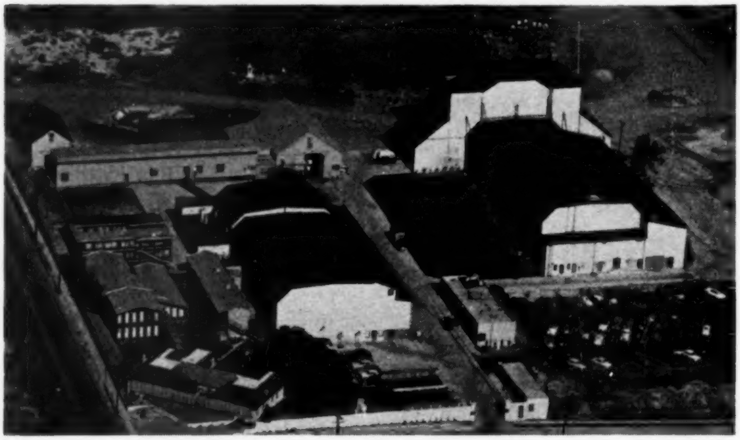

Fig. 6. ABC Television Center, Hollywood, Calif.

devices at least temporarily adapted from motion picture studio production techniques. Additional freedom in set lighting is appreciated by the motion picture cinematographers who are finding a place in the new medium.

The Navy is studying the effectiveness of television as a medium of mass training. The research is centered at the Special Devices Center, a field activity of the Office of Naval Research. Several experimental telecasts to classes assembled at Naval Stations have already taken place.

Use of Films in Television

During the past year the use of film programs on television expanded in volume and improved in tone quality. Several production

companies are regularly supplying program material as well as commercials for television usage that are specially prepared from script writing through laboratory processing of the composite prints. Efforts of this sort have led to the development of production techniques using several cameras operating simultaneously on a single scene and have permitted very rapid and relatively inexpensive production as well as dramatic techniques impossible in a television studio.

Some experiments have been conducted with a view to filming live television programs in the studio simultaneously with the over-the-air action, or during dress rehearsal. This might lead to the use of such films in place of video recordings.

In television studios background process projection is becoming more prevalent. The Holmes Projector Co. has developed a new machine for this purpose with a high efficiency shutter cycle.

Video Recording

The over-all quality of video recordings has improved considerably. More stable operations resulting from larger volume of recordings and improved original picture material are chiefly responsible. Specialized control devices for the recording operation and better liaison with motion picture laboratories rather than radical departure from previous methods have been the rule.

The widespread use of the Type 5820 image orthicon tube in the studio has provided better original material for the recordings which appears to be a very large factor in the results obtained. Reviews of video recordings have led to more emphasis on studio lighting which in turn has led to better recordings.

Producers' Service Co. has developed a 16-mm camera for video recording. This is of the mechanical shutter type. Preliminary experiments are being conducted in the recording of color television. Up to the present extremely large aperture lenses have been required.

Television Recording

The increased use of 16-mm sound recording by the television industry and the desire for improved sound quality have resulted in RCA's modification of 35-to-16-mm sound reduction printers for various domestic laboratories. The modified printers have lower flutter, double speed of operation and, in general, improved performance.

The high-frequency biased direct-positive variable density recording system mentioned in last year's Progress Report has been reduced to production practice in the recording of 16-mm films for television.

Theater Television

Considerable progress was made in 1949 toward establishing theater television as a regular commercial service.[41-44] However, one of the major problems, that of program distribution, remains unsettled. The cost of high-quality programming makes it desirable to link many theaters so that all can show the same program simultaneously and the cost per theater will be low. Two means of linkage are under consideration: (1) use a licensed common carrier now operating video distribution facilities, or (2) set up privately owned facilities. Because current carrier facilities are limited and rates are high, theater owners have been investigating the latter possibility.

Twentieth Century-Fox Film Corp. and Paramount Pictures, Inc., have experimented with micro-wave relays for linking theaters operating on experimental licenses granted by the Federal Communications Commission. Because of numerous requests from theaters for commercial licenses, the FCC requested that Twentieth Century-Fox, Paramount, and the Society of Motion Picture Engineers prepare answers to a series of specific questions relating to specifications and spectrum required for a nation-wide, competitive, series of theater television networks.

Along with the data submitted in answer to these questions, each group petitioned the FCC to hold public hearings on the allocation of frequencies for the sole use of theaters for program distribution. The Theatre Owners of America, Motion Picture Association of America, and many independent theater circuits submitted similar petitions. Other urgent business before the FCC has held up such a hearing but it is expected shortly.

Twentieth Century-Fox completely engineered a network of 24 theaters in a 400 sq mi area around Los Angeles, including program originating facilities and micro-wave distribution facilities. They have indicated that such a network could be in operation in a year after commercial licenses were granted.

The first production-type theater television equipment was sold in 1949. While RCA had already delivered a number of equipments to Twentieth Century-Fox, Warner Brothers and the Army Signal Corps, these were intended primarily for experimental use in evaluat-

ing and developing this new medium. During 1949, however, the first production RCA Direct Projection model was sold to Fabian Theatres Corp., for installation in the Fox Theatre in Brooklyn. A second unit was sold to American Theatres Corp., and installed in their Pilgrim Theatre in Boston. Paramount Pictures, Inc., has a permanent installation of their "Intermediate Film" equipment in the Paramount Theatre in New York and this year installed an equipment in their Chicago Theatre in Chicago.

Early in April, RCA first publicly demonstrated its new model "Direct Projection" equipment before the Society of Motion Picture Engineers. In this unit, the optical elements were reduced from the 500-lb, 42-in. spherical mirror and 21-in. glass corrector lens used in the early equipments to a 50-lb, 20-in. mirror and $15\frac{1}{2}$-in. moulded plastic lens. The optical barrel, or projector, was separated from the control equipment so it could be installed in the auditorium at the correct projection distance from the screen and the controls could go in the projection room.

In June this equipment was installed at Fabian's Fox Theatre in Brooklyn to bring the Walcott-Charles heavyweight championship fight to an overflow crowd of spectators almost 1000 miles from the scene of the event. The fight was simultaneously shown at the Paramount Theatre using their "Intermediate-Film" equipment.

Both RCA and Paramount demonstrated their equipments to the Theatre Owners of America at their convention in Hollywood in September. Paramount's equipment featured a new high-speed drier which reduced the time between photography and projection to 20 sec.

At the Theatre Equipment and Supply Manufacturers' Convention in Chicago, RCA demonstrated its equipment to 2500 theater exhibitors and equipment manufacturers. The demonstration featured a professional middleweight fight staged in the NBC studios and sent by direct line to the projection equipment at the Stevens Hotel. This is the first time an official match was staged in a broadcast studio specifically for a theater-type audience at a remote location.

The 1949 Baseball World Series was shown to paying audiences in the Fox Theatre, Brooklyn, the Pilgrim Theatre, Boston, and the West Side Theatre, Scranton, by means of direct projection equipment. It was also shown in the State-Lake Theatre in Chicago by means of film recorded on Paramount's equipment in the Chicago

Theatre across the street. Two Milwaukee theaters showed the Series on 7 × 9 ft screens set up on their stages using smaller direct projection equipment.

The Pilgrim Theatre in Boston showed a series of three Notre Dame football games. The final game of the series was also shown in the Fox Theatre in Brooklyn.

The Fox Theatre in Brooklyn worked with the Board of Education in a public service experiment. On a week-day morning they opened their doors free to New York High School students and their teachers who witnessed a morning session of the United Nations.

In addition to the intermediate film storage method and the instantaneous method of television projection the Swiss eidophor system, which uses an auxiliary light source and is still in the development stage, offers a means of providing adequate screen illumination for large theaters.[45]

C. W. Handley, *Chairman*
J. E. Aiken
L. W. Browder
G. H. Gordon
R. E. Lewis
W. A. Mueller
W. L. Tesch
J. W. Thatcher
W. V. Wolfe

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The Shape of the Television Screen

By RUDY BRETZ

Television Consultant and Producer; Head of Television Dept., Dramatic Workshop and Technical Inst., New York

Summary—The standard aspect ratio of the television screen is four units of width to three of height. When the picture is originally scanned on the target of the image orthicon tube, it is a rectangle of this proportion. The pictures that are viewed by the public on many home receiver screens, however, bear little resemblance to the 3 by 4 rectangle, and greatly alter the framing and composition which the cameraman originally created. The fault is in the home receivers; films and live television pictures suffer equally in this regard. The general adoption of a rectangular tube will alleviate this problem somewhat, but a large share of the trouble arises from receivers which are improperly adjusted as to picture size.

The height, width and centering controls on a television receiver are usually adjusted only by a more or less competent serviceman, but on many sets they are not too well hidden, and the owner of the set may alter them from time to time. The result is that a certain proportion of sets are out of adjustment in regard to picture size. This maladjustment is usually made in the direction of overscanning of the receiver tube, since the results of underscanning are much more noticeable (Fig. 1).

Early in 1948, WABD in New York received so many complaints from clients who had failed to see their entire advertising messages on home receivers, that they set out to determine exactly how much loss was sustained by the average set. A test chart was transmitted (Fig. 2) with numbers at the edges reading in toward the center, and the audience was asked to report which numbers were visible. On the basis of 50 replies tentative conclusions were announced. These were stated in terms of marginal losses, but for the purposes of this discussion I have translated them into terms of picture area. The study was conducted by Otis Freeman, now assistant chief engineer at WPIX. These were the general findings:

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only 26% showed 94% or more of picture area;
31% showed 88% to 94%;
33% showed 81% to 88%;
6% showed 75% to 81%; and
3% showed 69% to 75%.

These very general figures are plotted in Fig. 3. This survey was made before the advent of the curve-sided and circular screens. All the receiver screens involved were roughly rectangular. The losses in picture area were due to improper picture-size adjustments of the receivers. There is no reason to believe that these same maladjustments do not still exist on most types of sets.*

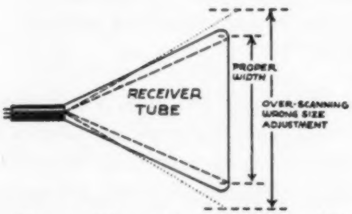


Fig. 1. When the height or width control on the receiver tube is set for too wide a sweep, the beam will strike the sides of the tube and only the center portion of the picture will be seen.

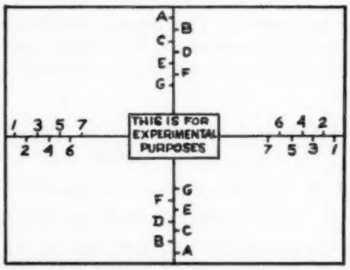


Fig. 2. Chart transmitted in WABD survey to determine loss of picture area.

A much more serious condition now exists in the circular screen. Even when height and width controls are in perfect adjustment on such sets, if the picture is to fill the screen, only 59% of the transmitted picture area can be seen (Fig. 4). Improper adjustment will increase this loss. Assuming that the same proportion of maladjusted receivers exists today, a survey similar to the above, based on 50 circular-screen sets would reveal tremendous losses of picture area. This has been calculated in a simple way: each of the values for per cent of picture area listed above has been applied against the 59% total possible picture area of the circular screen. Thus 94% of the picture

* The published results were as follows: "If there is an 8½% margin between the vital information and the top and bottom edge of the transmitted picture, at least 96% of the receivers will show this information vertically. Horizontally, if we leave a 13% margin between the vital information and the edges of the picture at least 95% of the receivers will show this information. With a 10% horizontal margin, 88% of the receivers will show it." Otis Freeman, *Television*, March, 1948.

area would become 94% of 59% of the picture area, or 55%. There are certain other factors involved, but the limited data available do not warrant any more detailed analysis. These figures are plotted in a curve (broken line) in Fig. 3.

The best-adjusted 26% would show 55% to 59% of picture area;
31% would show 52% to 55%;
33% would show 48% to 52%;
6% would show 44% to 48%; and
3% would show 41% to 44%.

Advertising claims would have the public believe that removing the mask and showing the entire face of the receiver tube (the "full-vision

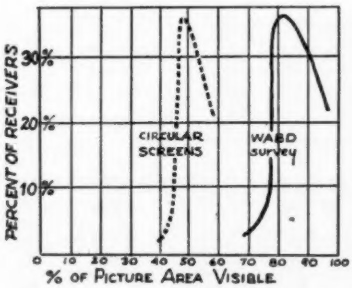


Fig. 3. Results on WABD survey calculated in terms of per cent of picture area visible. Broken line indicates possible results if a similar survey were conducted among the same number of circular-screen sets.

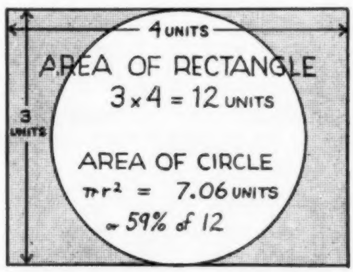


Fig. 4. Relation of area of 3 by 4 rectangle to area of circle. The circular area is only 59% of the size of the rectangle.

screen") somehow gives more picture, showing areas of the receiver tube on which all along there have been picture areas which the rectangular mask of the "ordinary" set has been cutting out. This is, of course, the reverse of the truth; removing the mask from the face of an "ordinary" receiver tube would simply reveal unused and dark areas. The broadcasting station sends a rectangular picture; it is rectangular from the moment it leaves the camera.

To fill a circular screen with this rectangular picture the set manufacturer must expand the height of the picture until it is equal to the diameter of the circle, and expand the width a proportional amount. The result is, of course, that figures appear much larger on the screen of a given size tube than they would if a rectangular mask were used.

The image of a wrestler, for example, may be 6 in. high on a 12½-in. receiver tube masked off for a rectangular picture (Fig. 5). When the mask is removed, however, and the picture expanded to fill the entire face of the circular tube, the image of the wrestler becomes more like 8 or 10 in. high—as large as it ordinarily would appear on an 18½-in. tube.

The close-up effect, however, carries no improvement in detail. The figure is still composed of the same number of picture elements; they are all enlarged together on the screen. The 6-in. image of the wrestler on the rectangular picture is scanned by 300 or 400 lines, possibly around 60 lines to the inch on the receiver screen. The 10-in. wrestler in the circular picture is composed of the same number

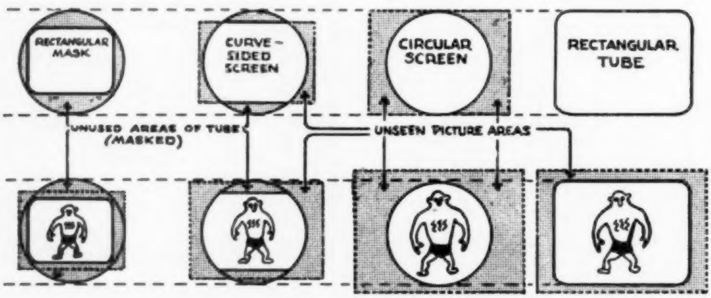


Fig. 5. Four methods of putting the rectangular television picture on the end of a cathode-ray tube. Each of these types of sets may be improperly adjusted and additional portions of the picture area may be lost, as indicated in the lower part of the figure.

of lines, but they are now spaced out to about 45 lines to the inch. Graininess appears worse from the same viewing distance.

The most serious handicap of this screen shape is the havoc it can play with picture information and carefully planned composition. A television sponsor on one of the New York stations advertised an item for 2.95 and was somewhat startled to see it come out for only .95 on a home receiver. This is loss of important information; other picture values suffer as greatly. Very few subjects which the camera can frame lend themselves to a satisfactory composition within a circular boundary. Pictures throughout history have nearly always been square or rectangular in shape. The predominant lines and planes in almost any scene are horizontal and vertical; the horizontal and vertical boundaries of the frame tie in with these and make unified and

pleasing compositions possible. It is only in the case of such things as miniature medallions or portraits from the horsehair sofa days that the public has been inclined to accept a circular picture. The subjects for these compositions were in the nature of Madonna groupings, and portraits, where curved lines which repeated the lines of the frame could predominate.

The broadcaster looks on the circular screen much as though he were a publisher putting out a magazine with the knowledge that a certain number of readers would, before reading it, take large shears, cut a circular piece out of the middle, and throw the rest away. He wonders to himself how long motion picture producers would stand for it if exhibitors insisted on running their pictures on circular screens. Many people in the industry throw up their hands in disgust and refuse to admit the existence of the circular screen at all. This point of view, however, is not shared by the advertiser, who must reach as many viewers as possible with his commercial message. Most manufacturers are planning to produce sets built exclusively around the new rectangular tubes. The saving in cabinet cost, a large item in set manufacture, is a primary concern. As soon as blanks of these tubes are available in sufficient quantity, practically all new sets will have screens of a rectangular shape. Until such time as the circular screen is obsolete, however, the broadcaster must make allowances.

Some cameramen prefer to set their view finders so they will overscan. By expanding height and width on the view finder tube the cameraman thus recreates the conditions of the average set. He takes a serious risk, however. His constant worry, the overhead microphone, although out of his frame entirely, might be painfully visible on well-adjusted sets.

Another solution which has been attempted is to overscan the target of the image orthicon tube. When this is done, the original picture includes border areas which would not ordinarily be scanned. The corners, at least, are not of broadcast quality, since they contain the images of the circular rim of the image orthicon photo-cathode. Assuming, however, that these distorted corners will be lost on all sets, this method has some value in that it permits the camera tube to be operated in a more efficient manner. Since the essential area of the picture (the portion which is visible on the average poorly adjusted receiver) is thus scanned from a larger area of the target plate, it is theoretically possible to put out a signal of better resolution.

However, no matter how large an area is originally scanned and

transmitted, the relative area of picture loss will be the same. The television production crew must constantly be reminded of the limited area of many home receiver screens.

CBS television has attacked the problem in a logical way. A celluloid sheet, outlined with an oval shape, is laid across every monitor and across the camera view finder screens as well. The cameramen call this the "elipse of essential information" (Fig. 6). It encompasses a little over half of the picture area. When a subject is considered absolutely essential (such as part of a commercial message or an object of importance to the plot), it must be kept within that area.

The producer of film for television use is vitally concerned with this problem of picture loss. Some television film cameramen are using special view-finder masks which cut out a certain portion of the picture area and insure a composition that will not lose anything essential on a poorly adjusted receiver.

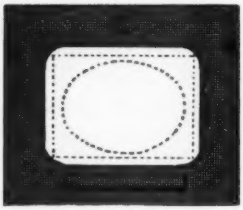


Fig. 6. CBS monitor overlay, indicating areas of picture loss.

Graphic artists and photographers have often had a better opportunity to work closely with television stations in the preparation of slides and title cards, and several formulas have been developed for establishing the safe and usable area.

For the sake of the discussion that follows, I have chosen to call this the "essential area." The total area which the camera will pick up, or which will be projected on the mosaic of an iconoscope tube, I have called the "picture area." The border area within, which when added to the essential area makes the picture area, may be called the "supplementary area." Information supplementary but not essential to the picture may be included in this region.

Compared below are three formulas which have been worked out for establishing these areas. The first, and I believe the easiest for the artist to use, was developed by Ray Sherwin when he was art director at Young and Rubicam (Fig. 7).

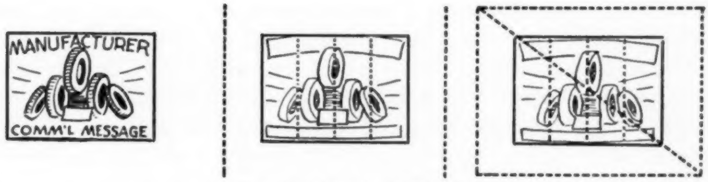


Fig. 7. Sherwin Method.

A. Start with the picture as it should appear on a poorly adjusted home receiver. This is the essential area.
B. Divide it into quarter sections vertically.
C. Add a border one quarter the width of the essential area on either side.
D. Run a diagonal through the corners of the essential area to locate the corners of the picture area.
E. Add top and bottom edges to the picture area.

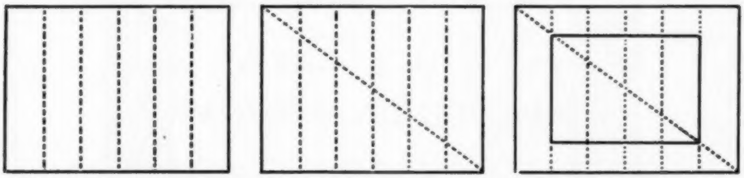


Fig. 8. Sherwin Method, reverse.

A. Lay out a picture area on the card. (The artist may prefer to allow a small margin around this to keep finger prints and edge damage out of the picture area.)
B. Divide it into six equal vertical sections.
C. Run a diagonal through the corners. The points where the diagonal intersects the first and the last dividing lines establish the corners of the essential area.

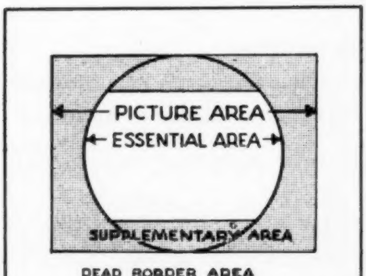


Fig. 9. WSYR-TV Method.

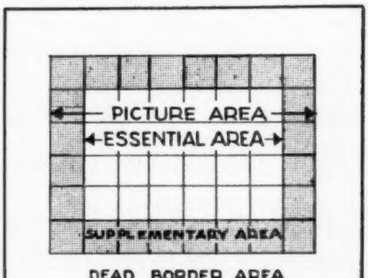


Fig. 10. WJZ-TV Method.

A. Starting with the $3\frac{1}{4} \times 4$ in. card, first mask off a $\frac{1}{2}$-in. dead border area. This leaves a picture area of $2\frac{1}{4} \times 3$ in. which is the standard picture area for lantern slides of this size.
B. Then draw a circle as large as possible within this area.
C. Draw horizontals across the circle $\frac{3}{8}$ in. in from the top and bottom of the picture area. This is the essential area.

Working in reverse, one may instead want to start with a blank card and determine the limits of the essential area within it (Fig. 8).

A good method was worked out by Bert Gold at WSYR-TV. This was used for the 3¼ × 4 in. slides and opaque cards on which that station had standardized, but it is adaptable for any size of work (Fig. 9).

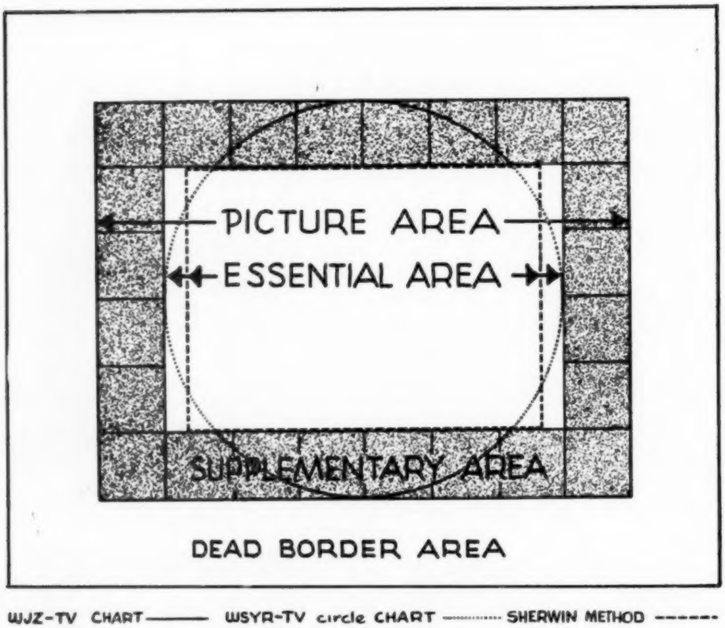


Fig. 11. Composite chart of three methods of establishing essential area.

The Gold method has one thing in its favor: the curved sides of the essential area probably make this closer to average receiver-screen shape and discourage the use of the corners where information is most often lost or distorted.

A third method is one which was devised some time earlier at WJZ-TV as a guide in the preparation of 2 × 2 in. slides. The picture area is divided into 48 squares (Fig. 10). The supplementary area is established as a border one square wide around the edges of the picture area. This comes to just exactly half of the picture area.

However, the essential area which is established by this method is wider than the standard 3 by 4 aspect ratio and might prove inaccurate at the sides.

All three of these formulas for establishing the essential area pretty well agree on its size, although proportions may vary somewhat (Fig. 11). In each case the essential area is roughly half of the picture area. This is a severe limitation, but one that is probably only temporary. As the proportion of sets built around the rectangular tube grows larger we can expect gradually to increase the size of the essential area.

In summary, here is a list of the unpredictable factors which determine the visible portion of a televised picture:

1. *Transmission*
   a. Studio cards: The framing of the camera may be hasty and inaccurate.
   b. Slides and film: The projector may be set up so that the projected image will exceed the area of the iconoscope mosaic.
2. *Reception*
   a. The receiver screen may be of some strange shape, with curved sides, or circular.
   b. The width, height and centering controls on the receiver may be improperly adjusted.
   c. In some receivers there may be distortions near the edges which would make lettering illegible.

The coming of the rectangular tube is a boon to the entire television industry, but the problem will not be entirely solved until some way is found for keeping home receivers properly adjusted for picture size. Perhaps an educational campaign on the part of the broadcasting stations is indicated. If a simple chart or picture were transmitted with the announcement that "if the entire design is not visible your set is out of adjustment," servicemen might find themselves obliged to adjust more sets properly. In any event the industry could well use further surveys, along the lines of Otis Freeman's study, to determine from time to time just how serious is this problem of the shape of the television screen.

Picture-Synchronous Magnetic Tape Recording

By D. G. C. HARE

The D. G. C. Hare Co., New Canaan, Conn.

And W. D. FLING

Fairchild Recording Equipment Corp., Whitestone, N.Y.

Summary—**Quarter-inch magnetic tape offers considerable economic and operational advantages for the recording of sound track material. The theory and basic design of a system which provides completely adequate synchronization of the sound with the picture are discussed. Various methods of automatically framing the sound track and picture are considered, and a simple system capable of rapid framing is described.**

Because it eliminates the need for careful control both during recording and processing and particularly since it allows immediate playback of a recorded track, the use of magnetically coated film stock has been the subject of considerable interest and investigation during the past two or three years. In addition, the use of such a recording medium results in a considerable saving since the stock can be erased and re-recorded a good many times. However, the problem of achieving good motion with sprocketed stock has not become easier but, on the contrary, has been to a certain extent increased, since in magnetic recording we need to maintain intimate and very constant contact between the magnetic material on the film and the surfaces of the record and playback heads. This is not always easy to do and the difficulty increases with the stiffness of the stock.

With the much thinner standard quarter-inch magnetic tape the problem of achieving really good motion is not difficult and, in addition, this tape costs from eight to ten times less than an equivalent footage of sprocketed stock. These two considerations have led, during the past year, to the development of several systems of synchronizing this unsprocketed tape with a projector. We would like to describe the system which was developed for the Fairchild Recording Equipment Corp. and which is incorporated in their Model 100-B Pic-Sync Recorder (Fig. 1).

Presented: February 15, 1950, at the Atlantic Coast Section Meeting in New York City.

We may state the problem quite simply. What is desired is to play back a sound track from a tape recorder with a speed regulation such that over at least a half hour the maximum time or displacement error of the tape with respect to the film is something less than one frame.

Driving the tape recorder capstan synchronously is not enough, since even though the slippage or creep of the tape around the capstan can be minimized to nearly any desired degree, the tape, whether it be

Fig. 1. Model 100-B Pic-Sync Recorder.

made with a paper backing or with a plastic base, is subject to stretch and contraction as a result of mechanical strains, as a result of temperature changes, and perhaps more important than either of these, as a result of humidity changes. Sprocketed film suffers from all these ills too, but in this case we never accumulate the bad results for more than a frame, always supposing, of course, that whatever stretch or contraction occurs is not so much that the sprockets cannot engage

their proper holes. In tape, however, we can have cumulative effects. For example, if a piece of film stretches 1% we would be out at most 1% of a frame. With a half-hour roll of tape, this 1% stretch would amount to some 18 sec or about 430 frames. To maintain one-frame accuracy in a half hour requires a cumulative speed control of the tape over this period of time of one part in something more than 40,000. Looked at this way, the problem seems a rather hopelessly formidable one. Actually, the solution is simple and, based upon the results of several hundred hours of commercial television operation, completely reliable.

There are several different approaches to the problem, all based upon the principle of putting on the tape during manufacture or at the time of recording, a mark—either physical or magnetic. the spacing of which will change with the stretching and contracting of the tape at exactly the same rate as does the program material which has been recorded. There are quite a few ways of doing this. One may make use, as has been done, of tape which during its manufacture has had marks placed on the back; one may, as has been very ingeniously done, make use of a control track which is recorded at right angles to the program track; one may record a subharmonic of the line frequency below the audible range, or the line frequency itself, or a harmonic of it in the audible range, and later chop it out; or one may record, as we have done, a control track as the modulation of a carrier which is placed at the extreme end of the high-frequency spectrum, say at something above 14 kc (kilocycles per second) and limit the playback response of the program channel to a kilocycle or so below this. In all cases, for reasons that will appear later, it is desirable from the standpoint of simplification that the control signals bear an integral relationship to the line frequency at the time of the recording. Obviously each system has a reason for its choice of control and the following is somewhat the way our reasoning went.

The printed tape requires two things: first, a special tape; and second, a photocell or other device for scanning the tape, which means additional components in the tape transport-pickup system. The system of recording a track at right angles to the program track requires both on recording and playback either an additional head or a special head. The subaudible signal, unless it is put on at a very low level, will usually result in hum components due to distortion products, and nearly always requires a modification of the record and playback channels since most recorders cut off somewhat above 30 cps (cycles per second). Further, it is generally true that both the

signal handling capacity and signal-to-noise ratio of most tape recorders is poor in the extreme low range.

In using a high-frequency carrier we, of course, pay the price of moderately limiting the high-frequency response, but since the resulting 13-kc upper limit is still not only well above the usable upper frequency range of most film systems, but also is above the reproducing range of most of the reproducing systems used in conjunction with the film, this is not a serious consideration.

Most professional recorders running at 15 in./sec have a guaranteed response of 15 kc, and by using this system we can record a control track on any tape recorder with only the addition of a simple bridging unit which is placed in the program channel just before the tape recorder. The tape can then be played back in synchronism with the film on any Pic-Sync recorder. This allows the user to record a sound track on available equipment, a consideration we believe to be quite important.

Having marked the tape either physically or by means of a control signal, our next question is the method of applying the control.

Since we have two units, the projector and the recorder, we can control either of them. We do not believe, for several reasons, that the control of the projector speed would result in the best practical system, and thus all of the following comments will refer only to methods of controlling the speed of the tape recorder.

If both the camera and the projector are driven by synchronous motors, they will move equal numbers of frames in equal time intervals if the time interval is measured in terms of the line frequency (as by a synchronous clock). On the tape recorder this means that in such an interval of time it must play back exactly the same amount of sound as was recorded, again remembering that the time interval is measured *in terms of the line frequency.*

As was mentioned before, the obvious thing to do is to use as a control track the line frequency or some multiple of it. If we do this, and on playback require that the difference between this control track frequency and the line frequency be zero at all times, we will have achieved our purpose. This is nothing more than a familiar servo regulator system. Of course, we cannot make use of the naive principle of merely amplifying the control track and causing it to drive a synchronous motor, since there is nothing in this system that tells us the difference between 59, 60 and 61 cps.

Perhaps the next obvious approach consists of recovering the control frequency and comparing it with the line frequency and using this

difference frequency to control the recorder speed. For example, let us suppose the line frequency at the time of recording was 60 cps and that this frequency was recorded on the tape as a control track. Further, let us suppose that between the time of record and playback the tape had stretched, so that if the recorder drove the tape at the same speed as it did at the time of recording, the control signal would be played back as 59 cps. For our comparison signal we might double the playback line frequency, which would be 120 cps, and obtain the difference between this and 59 cps from the tape. This difference frequency would be 61 cps, and if this frequency were used to control the speed of a synchronous motor, the tape would be driven faster than it was at recording, and at first glance one would assume that the 59 cps would come off as 60 cps thus correcting for the tape stretch. However, the difference frequency between 60 and 120 cps is 60 cps, which would give us 59 cps which, so to speak, is where we came in.

It is obvious that such a simple system as this will result in reducing the error by only a factor of two. If we use a higher multiple of the line frequency we could reduce the error in direct proportion to the multiplying factor. It is quite apparent that to make a correction to an accuracy of one part in 40,000 this simple method is impractical.

The problem of getting an error correction without having an error is a familiar one to those who work with servo mechanisms and the solution is basically quite a simple one. What one does is to examine the residual error over a period of time and *correct* the *correction* in accordance with this residual. This is what is familiarly known as "integral control." In our case it merely means that we want the time integral, over some period, of the difference between the line frequency and the control track frequency to be zero or, more exactly, that it not change with time. That is,

$$\int_0^T (f_l - f_c)dt \neq f(t) \tag{1}$$

where f_l = line frequency at playback,
f_c = control track frequency at playback,
T = time limit of integration, and
t = time.

There are several ways of achieving this result. The one chosen, we think, represents a fairly simple approach. It is based upon the fact that by definition frequency is equal to the rate of change of phase. Using this definition the above equation becomes

$$\int_0^T \left(\frac{d\varphi_l}{dt} - \frac{d\varphi_c}{dt}\right) dt \equiv \varphi_l - \varphi_t \neq f(t) \qquad (2)$$

where φ_l = phase of line current or voltage, and
φ_c = phase of control track current or voltage.

If we then use a control based on phase relationships rather than on frequencies we automatically achieve the desired integral control.

In its simplest form such a system of control is one in which the necessary speed correction is determined by the phase relationship between the control track frequency and the line frequency. If the system is such that all the corrections can be achieved during some part of a single cycle, then regardless of playback time we will never have a time error greater than the period of a full cycle of the line frequency. Figure 2 shows a block diagram of such a phase control system. The control track recording system is shown in the upper part of the figure and is completely straightforward. It consists merely of a 14-kc oscillator modulated with the line frequency, a high-pass filter to remove the line frequency, a volume control, and a bridging resistance which is connected directly to the record head. As mentioned before, this control track frequency can also be bridged in ahead of the recording amplifier permitting control track recording on any 15-in./sec tape recorder.

In playback we amplify the control track signal along with the program in the first two stages of the playback amplifier. In the Model 100 Fairchild recorder a playback volume control is placed in the front panel which makes for convenience in separating the control signal and the program. This is done by means of a rejection filter tuned to 14 kc and placed in series with the line to the pad. Ahead of this rejection filter the control track frequency is bridged out through a tuned network, after which it is amplified, further filtered, demodulated and limited. Following this limiting it goes to a power amplifier which feeds one phase of a two-phase servo motor at a level of about 15 w. On this phase, then, we have the control signal which was originally the line frequency at the time of recording. The other phase of this motor is supplied directly from the line. Figure 3 shows the phase-torque curve of this type of motor, the phase indicated, of course, referring to the relative phases between the two windings, and the curve shown being for a single motor speed. For any other speed we get a similar type of curve except that the maximum torque will be larger or smaller.

A simple example may help to visualize the way in which this phase-

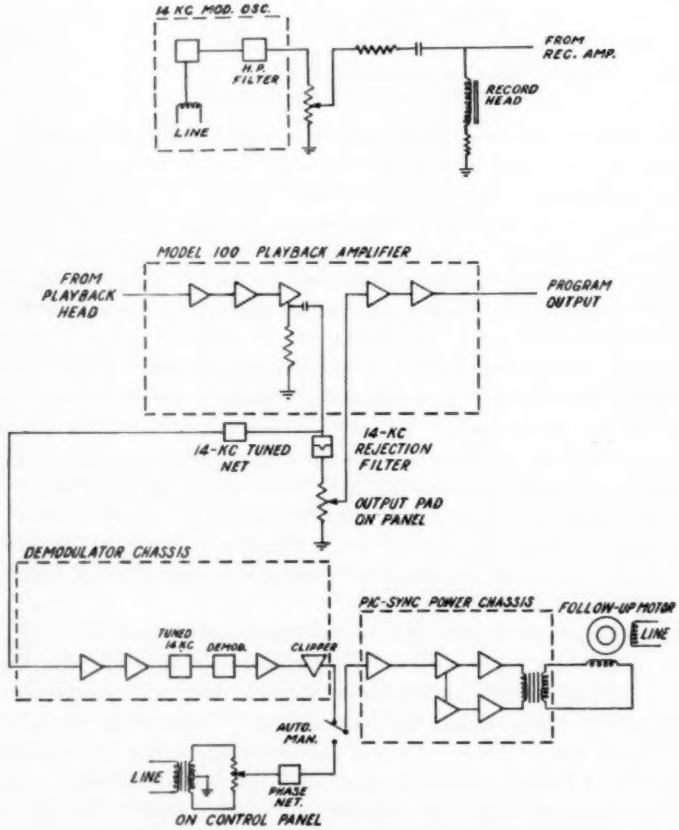


Fig. 2. Block diagram of phase control system.

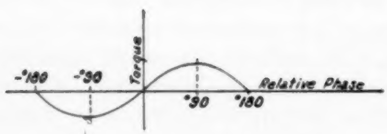


Fig. 3. Phase-torque curve for two-phase servo motor.

torque characteristic can be used to obtain the required speed control. Let us suppose, for example, that the frequency coming off the tape without any correction is very close to the line frequency—perhaps 59.8 cps. On the two phases of the servo motor we have, thus, two slightly dissimilar frequencies, and, hence, the phases of the

currents in the two windings are slowly varying with respect to each other. This, of course, means that the torque will also be slowly varying, going from zero to a maximum in one direction and back to zero and to a maximum in the other direction.

Now, if the motor is connected into the system in such a fashion as to reduce the tendency of the phase to change, it may be seen that under suitable conditions the speed will change to a value such that there is a constant phase difference between the currents in the two windings. That is,

$$\varphi_1 - \varphi_c = \text{const} \neq f(t \qquad (3)$$

Recalling equations (1) and (2) this is just the condition that is needed for our control.

This phase control method can be applied to a recorder-projector system in several ways. We can control the speed of the projector, the speed of the tape recorder main drive motor, the position or setting of a speed changer in the tape recorder, or we can "rate" the main tape recorder drive system. This latter method is the one used in the Pic-Sync recorder and is a broad application of the basic Synchroll principle which is used in the normal drive of this recorder. Since the details of this type of drive have not been published, it might be in order, for the benefit of those not familiar with it, briefly to digress for the explanation of its principles.

The development of the Synchroll was predicated upon the reasoning that in a sound system we require the drive to perform two entirely different functions. First, it must provide, over rather short intervals of time, extremely constant speed. Second, the playback time of the recorded program must, to a very high degree of accuracy, equal the time of recording over, say, a half-hour interval. In the past, most drive systems have tried to achieve these two somewhat dissimilar objectives with a single means or, more frequently, have ignored one in favor of the other. For example, the puck or friction roll drive when properly constructed is capable of having very precise short-term speed control, but all puck or other friction drives either slip or creep to a greater or lesser degree; and what is worse, this slip or creep may be, and all too frequently is, quite variable. The same remarks, of course, apply to belt drives. Gear drives, on the other hand, if the main drive is synchronous, will provide an absolutely synchronous drive system, but the difficulties of getting the tooth ripple out of the gear drive are all too well known to anybody who has tried it. We can, of course, eliminate this gear ripple if we use a

sufficiently soft coupling, but as soon as we do this we have a system which is also soft, and which not only takes a long time to settle down but which when disturbed by a sudden change of load will give rise to a very disturbing wow.

The elements of the drive are shown in Fig. 4. Disregarding the right-hand motor for the moment, we have on the upper end of the motor shaft a conventional puck drive. The bottom of the motor shaft is coupled to a gear train which, in turn, is coupled to the flywheel shaft. Both the motor and flywheel shafts are isolated from the gear train with soft couplings. If, for the moment, we consider the puck drive separately, we have a drive system which has a characteristic rigidity or stiffness but which, in common with all friction drives,

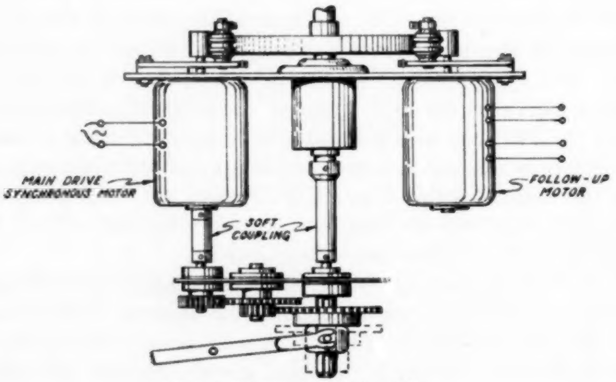


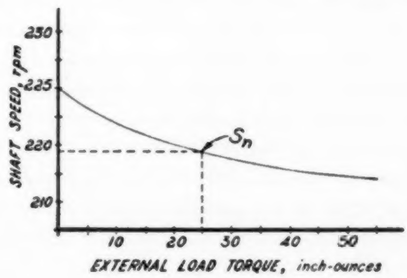
Fig. 4. Elements of the drive.

tends to slip or creep. Figure 5 shows a typical speed-torque curve for such a drive. We deliberately chose the diameters of the motor pulley and the flywheel such that their arithmetical ratio is a percent or two lower than that of the gear train. Thus if the puck did not slip it would drive the capstan a percent or two faster than would the gears. The gears coupled to the capstan through the flexible shaft can then be considered as a load which causes the puck to slip just this percentage. Figure 5, for example, shows that a load of 25 inch-ounces would be required to reduce the speed from 225 rpm to 218 rpm. The soft couplings between the gear drive and the motor and capstan effectively filter out any gear ripple, while the stiff coupling of the puck effectively eliminates the hunt and softness due to this flexible coupling.

This type of drive can be looked at in two ways. It can either be considered as a puck drive with a follow-up or rating system which keeps it synchronous, or it can be considered as a gear drive with a very high amount of damping supplied by the puck.

For the Pic-Sync operation we consider the drive from the first of these two viewpoints. In this operation the gear drive is disengaged although the main motor is still coupled to the flywheel through the puck. The follow-up motor, which is the servo motor shown in the block diagram, whose speed or torque is proportional to the relative phase between the line and the control signal, is also coupled to this flywheel through a puck. The phase-torque characteristic of this motor then provides a varying load on the main drive motor, in some cases assisting and in others retarding. Since this is what is commonly known as a "closed loop" system, there is no need for a gear coupling

Fig. 5. Typical speed-torque curve for the drive.



to the capstan. As previously explained, as the tape comes up to speed, the control signal appears on one winding of the follow-up motor, and the phase of the current in this winding will be varying slowly with respect to that of the line phase. The system is so connected that as the phase varies, the torque of the follow-up motor changes the speed of the tape in such a fashion as to oppose the change in phase. Given enough power the follow-up motor will hold the speed at a point such that the frequency of the control signal is equal to that of the line frequency. At this point the phases of the currents in the two windings are such as to provide just the torque necessary to load the main drive puck system to this proper speed. This is a stable operating condition, and since the control track frequency and the line frequency are now the same, we are playing back our program at a rate which referred to the line frequency is exactly that at which it was recorded. If the projector is driven by a synchronous motor, the program on the tape will be in exact synchronism with the picture.

If the system is tight enough, that is, if the follow-up motor has adequate power, all corrections will be made with a phase change of not more than ± 180 degrees, so that no matter how long the playback time, the error between the tape and projector will never be more than the period of a single cycle of the line frequency. This, of course, assumes a damped steady state response. A very satisfactory aspect of this type of rating system is that, just as in the case of the standard Synchroll drive, the main drive motor and its puck coupling provide a tremendous amount of "built-in" damping for our rating mechanism.

At the lower left of Fig. 2 is shown an additional input to the Pic-Sync power amplifier. This allows the control phase of the motor to be fed directly from the line in such a way as manually to adjust the speed of the recorder. This is normally not used in Pic-Sync operation but is introduced merely as a convenience for the purpose of changing the time of playing back an uncontrolled program. It could, of course, be used for a manual framing device if desired.

The question of the effect of splices is frequently raised. Naturally, if the tape is properly spliced before recording, the splice has no effect. If the tape is cut and spliced after recording, as in editing, we will probably cut out something other than an integral number of 60-cycle control waves. When the splicing passes the playback head, there will then be an abrupt change in the relative phases of the line and control frequencies. The transient response of this system is such that there is practically no audible effect from this abrupt change and the damping is sufficient so that there is no tendency to hunt, the follow-up motor merely taking a new position of equilibrium. In so doing it may pull ahead a half cycle or fall behind a half cycle. The expected accumulated error from a number of splices is a probability function which depends upon the constants of the system and which is not easily calculable. Our experience has shown that on the average the error due to random splicing is a good deal less than a quarter of a frame per splice. Since at 15 in./sec the wavelength of a 60-cycle signal is approximately one-quarter inch, it is a relatively easy job to make a good approximation to ideal full-wave splicing if such precision should ever be required.

Performance tests of the over-all system accuracy have repeatedly shown an accumulated error of less than one-quarter frame in a half hour. These tests were necessarily laboratory ones and do not mean very much in terms of commercial operation. We believe that perhaps the best evidence of the stability of this control system is that

two machines which have been in daily use at WCBS-TV have an operating time of well over one thousand hours and have been used many times to provide the sound track for telecast programs.

There are two primary uses of a Pic-Sync recorder. One is to provide a sound track which is later dubbed onto film and eventually printed as a standard optical track on the picture stock. There are obvious economic advantages to using tape for this purpose. First, it permits immediate playback of the sound track without the necessity of the controlled processing of the optical track. Second, the cheapness and re-usability of tape make it economically practicable to record a large number of tracks simultaneously if desired, from which the master track can be mixed. Third, again as a result of its cheapness and re-usability, it is coming into increasing use as a safety track in conjunction with standard film recording. These, of course, are only a few of the uses of synchronous tape recording as an intermediate step to a final optical track.

The other major field for picture-synchronous tape recording is in its direct use as a sound track for projected material. In order to use the tape in this fashion one must have a simple and reliable method of bringing the sound and picture into exact frame synchronism at the start of the program. Since the projector and recorder are normally driven separately, this requires that the initial speed and movement of the medium on one be controlled with relation to these factors on the other.

There are two approaches to this problem. One of them consists in putting on the tape and film leaders a series of marks which bear some fixed relationship to the number of frames, and with the use of some monitoring method, properly adjusting the speed of the recorder and projector. This can be done visually, aurally or automatically, and in a proper system will result in exact framing at the start of the program.

The other method is based on the assumption that during the time it takes a normal five- or ten-second leader to be played, the effects of tape stretch, contraction, and even slip, are completely negligible. This we believe to be true for all high-quality tape recorders. Then one method, and a simple one, of bringing sound and picture into frame is merely to determine the relative starting times of the recorder and projector and either cut the leader to compensate for any difference or to start one or the other with the proper delay. This can and has been done with completely satisfactory results, but it

requires an individual and very precise adjustment for each recorder and projector and, much more important, requires that the relative starting times remain constant from day to day and temperature to temperature. This requirement is seldom if ever closely approximated.

Another of the unmarked leader methods eliminates these latter difficulties. It involves the comparison of the projector sprocket rotation with the capstan rotation of the tape recorder. In this system, the information regarding the sprocket rotation is transmitted to the tape recorder by means of a pair of very small self-synchronous (Selsyn) motors, one of which is fastened to the sprocket of the projector, and the other to one side of a differential in the tape recorder. The other side of this differential is connected, through a gear train of proper ratio, to the capstan drive shaft. The output of this differential then will be a measure of the difference of rotation between the capstan and the projector drive sprocket. If we choose the gear ratio such that one revolution of the capstan corresponds to the same number of frames of program material as does one revolution of the drive sprocket, the output shaft of the differential will remain stationary for synchronous operation. Any rotation of this output shaft is an indication of a framing error and we cause it to correct the speed of the recorder in such a direction as to reduce this error to zero. By suitable and rather simple means it is possible to store rather large framing errors and to correct these errors rapidly to a small fraction of a frame. For example, the recorder and projector will, if started at the same time, be out of frame by something between three and ten frames at the end of the leader. This error can be corrected, to a quarter of a frame within a matter of two to four seconds.

Inasmuch as this article is a transcript of the rather informal presentation at the meeting, no detailed discussion of the construction of this framing device is included. It is, however, worth while to point out that the device is arranged so that when the framing error has been corrected and the control track takes over the control of the speed of the tape recorder, the error-storing mechanism is disengaged from the differential and not re-engaged until the machine is turned off. This eliminates the necessity of manually resetting to zero at the start of a new program and it also makes it possible, when using tape that has been recorded under suitable conditions, to start and stop the projector several times during the program with a negligible framing error.

The Open-Air Concentrated-Arc Lamp

By W. D. BUCKINGHAM

Western Union Electronics Research Laboratories, Water Mill, L.I., N.Y.

Summary—**The open-air concentrated-arc lamp is a new form of the concentrated arc which operates in the open air and does not require any enclosing bulb or protective atmosphere. The light source is a sharply defined, circular spot which is formed on the end of the electrode by a thin film of incandescent molten zirconium. The lamps can be operated from alternating or direct current and can be made in sizes up to several kilowatts. A 1-kw lamp operating on alternating current draws 18 amp at 55 v and produces 3000 candlepower from a spot 5.4 mm in diameter whose average brightness is 130 c/sq mm. The radiation has a continuous black-body type of spectral distribution and a constant color temperature of 3600 K. Due to a unique operating principle whereby the zirconium metal is constantly renewed from its own products of combustion, the lamps can have lives of several hundred hours. The exhaust products are nontoxic and the electrodes are replaceable. The lamp is characterized by extreme stability and ease of operation. It is expected to find application in projection, television, flood and spot lighting and other fields which require intense light sources.**

The Western Union Open-Air Concentrated-Arc Lamp is, as its name implies, a concentrated-arc lamp[1] which operates in the open air without an enclosing bulb or protective atmosphere. While this new lamp is fundamentally a concentrated arc, in that the source of the light is a thin film of molten metal, its characteristics are quite different from those of the earlier types. Chief among these differences are open-air operation, an increase in operating voltage from 20 to 55 v, operation from either direct or alternating current and an increase in brightness from 50 to 130 c/sq mm (candles per square millimeter). An outstanding characteristic is its stability or steadiness of operation.

The theory of the new lamp can be best explained by a review of the

[1] W. D. Buckingham and C. R. Deibert, "Characteristics and applications of concentrated-arc lamps," *Jour. SMPE*, vol. 47, pp. 376–399; November, 1946.

Ibid., "The concentrated-arc lamp as a source of modulated radiation," *Jour. SMPE*, vol. 48, pp. 324–342; April, 1947.

Presented: October 14, 1949, at the SMPE Convention in Hollywood.

operation of the original concentrated-arc lamp. In the older type of lamp, the cathode, or negative electrode, consists of a tube of tantalum, or some other metal with a very high melting point, which is filled with zirconium oxide, ZrO_2. The positive electrode, or anode, is a simple metal plate with sufficient radiating surface to limit its temperature to a dull red heat during operation. After the enclosing bulb has been evacuated and filled with argon gas, the cathode is activated or formed. In this process a d-c arc is established between the anode and the metallic side wall of the cathode tube. The cathode tube soon becomes hot and heats the zirconium oxide within to a temperature at which the oxide becomes electrically conductive. At ordinary temperatures, zirconium oxide is an excellent insulator. The arc then strikes from the anode to the oxide and, under the intense ionic bombardment of the arc, the surface layer of the zirconium oxide is reduced to its two components, zirconium and oxygen. Thus, a thin film of zirconium metal is formed on the end of the cathode. During operation of the lamp, the metallic film is maintained in a molten state by the heat of the arc. This pool of molten metal is the chief source of the visible radiation from the lamp. Having been once formed during manufacture, the film of zirconium metal remains on the cathode so that on subsequent starts the arc establishes between the anode and the zirconium directly.

Even though the zirconium is maintained in a molten state during operation of the lamp, there is but little loss by evaporation for, as the zirconium leaves the surface of the electrode, it becomes ionized and is drawn back to the cathode. Any zirconium which does escape from the cathode is replaced by reduction of the underlying oxide.

These processes result in an excellent lamp with a life which may reach 1000 hr. The light source is a sharply defined luminous circular spot which is fixed in position and uniformly brilliant with an average brightness of about 50 c/sq mm. Thousands of them have been manufactured and they have found application in hundreds of different fields.

The investigation which resulted in the development of the open-air lamp started from the observation that the brightness of the concentrated-arc lamp drops sharply during the first few minutes following the initial forming operation. By the end of the first hour of burning the brightness has stabilized at or near 50 c/sq mm, which value is less than one-half of its initial brightness.

This decrease in brightness and light output was thought to be due

to a thickening of the zirconium-metal film which forms on the surface of the cathode. When first formed, the film is microscopically thin so that it can conduct but little heat from its molten center to the metal side walls of the cathode tube. With continued operation, however, more zirconium metal is produced. The film becomes gradually thicker and conducts more heat from the incandescent spot; and the brightness drops.

If all of the oxygen, which is released by the reduction of the oxide, remained free within the bulb, a state of equilibrium would soon be reached in which the number of molecules of zirconium oxide being broken into its components by the action of the arc would be exactly balanced by the atoms of zirconium and oxygen which were recombining to form zirconium oxide and the zirconium-metal film would remain very thin. In the ordinary concentrated-arc lamps, however, some of the oxygen combines with the hot molybdenum of the anode to form a molybdenum oxide. This oxygen, having been captured by the anode, cannot return to the cathode, so the zirconium-metal film gradually thickens.

As a test of this theory, a few lamps were constructed in which all of the metal parts, which become hot during the lamp operation, were made of platinum, a metal which does not readily combine with oxygen even when it is white hot. When tested, these lamps did maintain their initial brightness.

It appeared that a new line of high-efficiency concentrated-arc lamps could be developed by using nonoxidizing material for the metal parts of the electrodes. Platinum could be used but it is very expensive. The small amount used in a 25-w lamp would cost $20; and for larger lamps, the cost increased sharply. A search was begun for relatively cheap nonoxidizing electrode material.

This work was interrupted by an experiment made with the lamps with platinum electrodes. Since platinum would not burn in the oxygen-argon mixture which filled the bulbs of these experimental lamps, it seemed reasonable to suppose that they could be operated in the open air without any enclosing bulb. This was found to be the case. The lamps operated at an average brightness of 130 c/sq mm. Part of the increase in brightness of the open-air lamps is due to the thinness of the zirconium-metal film and part is due to the energy released by the zirconium in recombining with the oxygen.

The voltage drop across the lamps was about 55 v. This figure compares with 20 v for the concentrated-arc lamp operating in argon.

This is a considerable advantage for it is much cheaper normally, to supply a 1000-w lamp with 18 amp at 55 v than with 50 amp at 20 v, as is required by the argon-filled lamp. It was found also that the lamps could be operated on alternating current if they were made with two similar zirconium oxide-packed cathode-type electrodes. This too, is of great advantage for alternating current is usually available and direct current can be secured only by rectification.

These characteristics of open-air operation, higher brightness, lower current and the choice of using either alternating or direct current, combined with the uniform brightness and stability of the concentrated arc, seemed ideal.

A wide variety of metals and alloys was tested in the search for a substitute for the platinum used in the first experimental lamps. None proved to be as satisfactory for the purpose as nickel. Nickel is classified in the same periodic family group as platinum and it has somewhat similar characteristics. When subjected to high temperatures in the presence of oxygen, it oxidizes very slowly. The first thin film of oxide which forms on its surface acts as a protective coating which retards further oxidation.

Zirconium oxide was used as the filling material for the first of the new-type electrodes. It worked fairly well but had two major defects. Zirconium oxide is a conductor of electricity only when it is heated to a dull red heat. Thus, it is difficult to strike an arc between such electrodes when they are cold. The arcs are started with a high-voltage pulse generated by a choke and vacuum-switch combination, such as is now used with the standard type of argon-filled concentrated-arc lamp. When zirconium oxide filling was used in the new electrodes, the arc had to be established first to the outer metallic tube. The heat of this arc then raised the zirconium oxide to the temperature where it became conducting and the arc would then strike to the oxide surface. This is the same sequence of events as occurs in the argon-filled type of concentrated-arc lamp during the forming operation. In the enclosed lamp the zirconium-metal film formed during manufacture is established for the life of the lamp. The open-air arc, however, must be reformed each time it is started, for the zirconium-metal film which is produced during operation burns to the oxide the instant the current is shut off. What was needed was some material that could be added to the oxide to make it conductive when cold so that the arc could strike directly to the oxide when the lamp was being started.

The second major difficulty with plain zirconium oxide as a filling material was the poor bond between it and the outer tube. The fused oxide bead which forms on the end of the electrode during operation could be easily knocked off.

A number of materials such as carbon, carborundum and other electrically conductive substances, which could withstand high temperatures, were mixed with the zirconium oxide filling in an attempt to make it conductive when cold. These either burned out of the mixture quickly or poisoned the oxide so that it would not maintain a normal-type concentrated arc. Zirconium-metal powder was tried as a filling material. This construction is shown in Fig. 1. It was pressed into the nickel tube under considerable pressure and then sintered at a bright red heat in an atmosphere of argon or nitrogen. It was hoped that the solid zirconium-metal core thus produced would bond tightly to the nickel tube so that, during operation, only the ex-

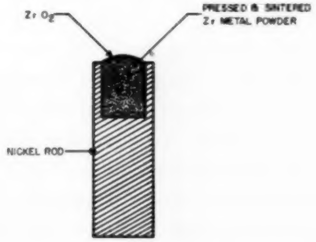


Fig. 1. Section through open-air type of electrode.

posed end of the zirconium would oxidize. If this oxide cap was thin, the starting spark could jump through it to the underlying zirconium metal to give easy starting.

Such electrodes did start easily the first time they were used but, after a few hours of operation, all of the zirconium metal had been progressively converted to the oxide and the electrodes were no better than those which had been packed originally with zirconium oxide.

The next step was an attempt to find some material that could be mixed with the zirconium metal which would protect all but the active end of the zirconium core from oxidation. Powdered nickel, in the proportion of about one part of nickel to three parts of zirconium-metal powder, was found to produce a mixture which would not progressively oxidize throughout its entire volume as had the pure zirconium. These electrodes would acquire only a thin cap of oxide at the active end and the underlying conductive nickel and zirconium

mixture remained to aid in starting the lamps. The zirconium oxide caps were well bonded to both the nickel tube and the underlying metal.

It has been found since, that an even better electrode is produced if a few percent of other materials which act as unrecoverable "catalysts" or accelerators are added to the zirconium nickel mixture. This apparently increases the electrical conductivity through the fused-oxide cap when the electrode is cold and thus aids starting.

The exact composition of the core mixture does not seem to be critical. At the moment, an electrode using 87% zirconium, 8.7% nickel and 4.3% other materials is giving excellent results. This mixture is pressed into the nickel cups under high pressure. The electrodes are heated in an atmosphere of nitrogen to a temperature of about 1000 C when a reaction takes place in the core material, as is indicated by a sudden glowing of the zirconium mixture. After this treatment, the core is very hard and the electrodes are ready for use.

When operating on direct current, one of these electrodes serves as the cathode. Copper has been found to work well as the positive electrode. Two of the sintered zirconium electrodes are used for a-c operation. This, of course, results in two equally brilliant luminous sources which are very close together. If a single source is required, the electrodes can be arranged so that one spot is obscured. For applications where a single luminous spot is not essential, the light from both electrodes of the a-c lamp can be utilized. In this case the luminous output of the a-c lamp is double that of the d-c type. The luminous spots of the a-c and the d-c lamp are quite similar in diameter and brightness. The major interest has seemed to be in the a-c version of the new lamp. For this reason, all of the characteristic performance data quoted in this paper are for a-c lamps.

Figure 2 shows one of the new lamps in operation. This is a 1-kw a-c lamp and the electrodes are arranged at right angles to each other. In the front view, the full end of one electrode can be seen. The luminous spot is very sharply defined. The arc stream itself is relatively nonluminous. This fact is demonstrated further in the side view photograph where the outline of the full-arc stream and flame are only faintly visible while the images of the molten zirconium pools have literally burned themselves into the film. Measurements show that the electrodes are 26 times as bright as the arc flame.

When the lamps are operated on 60-cycle alternating current, the

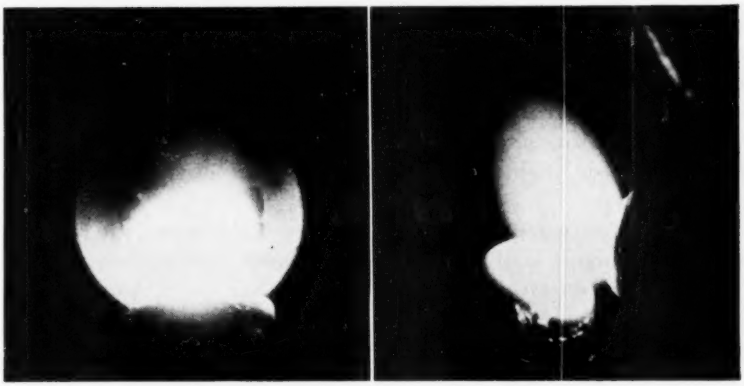


Fig. 2. Photograph of 1-kw arc in operation: left, front view; right, side view.

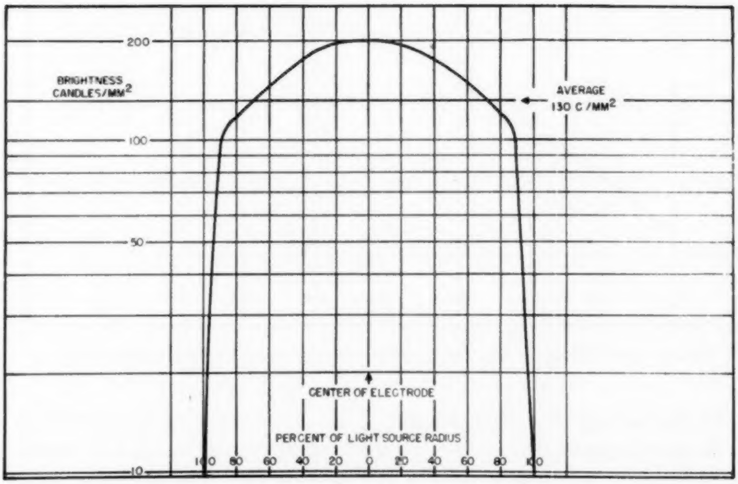


Fig. 3. Brightness distribution across source, 1000-w open-air concentrated-arc lamp.

light has a 16% modulation at 120 cycles. The modulated component originates largely in the arc stream.

The brightness distribution across the luminous spot on the electrode of a 1000-w lamp is shown by the curve of Fig. 3. The increased brightness at the center of the spot is due to the light from the arc

stream which is superimposed upon that originating from the molten zirconium pool. The temperature and brightness of the pool are a characteristic of the zirconium itself and depend upon its melting and boiling temperatures, electron emission characteristics, thermal conductivity and other physical and electrical properties. For this reason, the intrinsic brightness of a lamp is substantially independent of its size.

If hafnium is used in the lamp in the place of zirconium, the brightness of the lamp is doubled. Hafnium is much too expensive, however, for commercial use.

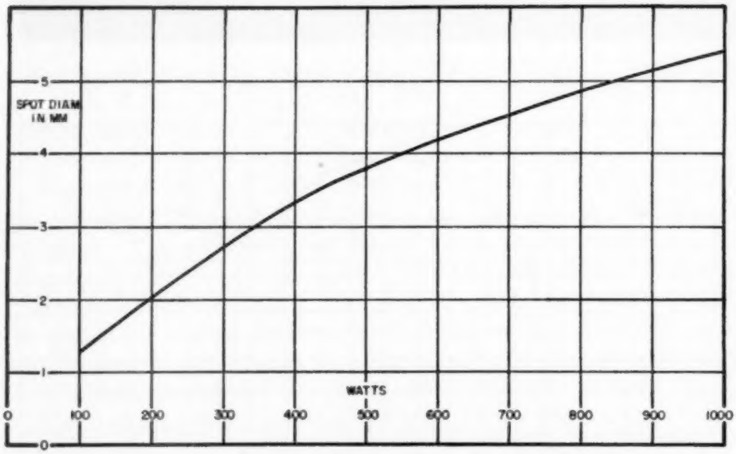


Fig. 4. Spot diameter vs. watts, 1000-w open-air concentrated-arc lamp.

As the wattage is raised, the luminous area increases in proportion to the power expended. The relationship between the spot diameter and the lamp wattage is shown in Fig. 4. The 1000-w lamp has a luminous spot diameter of about 5.4 mm.

An electrode of a given diameter can be operated over a considerable range of current. If the input is too small for the size of the electrode, the luminous spot will cover only a small portion of its end. It may be unstable in its position, for it can establish itself anywhere on the end of the electrode and it may wander during operation. The brightness and efficiency will be somewhat below normal because of the power radiated by the proportionately excessive size of the elec-

trode. At the other extreme, if too much power is put into an electrode, the luminous area will spread to the sides, and the end of the electrode will become rounded and hemispherical. Ordinarily, an electrode works reasonably well over a two-to-one range in current.

As the current is increased the voltage decreases, as is shown by the curve of Fig. 5. This shows that the new lamp has a negative resistance characteristic, like any other arc, and must be operated with proper ballast in its power supply. The voltage drop across a lamp depends upon both the current and the length of the gap between the electrodes.

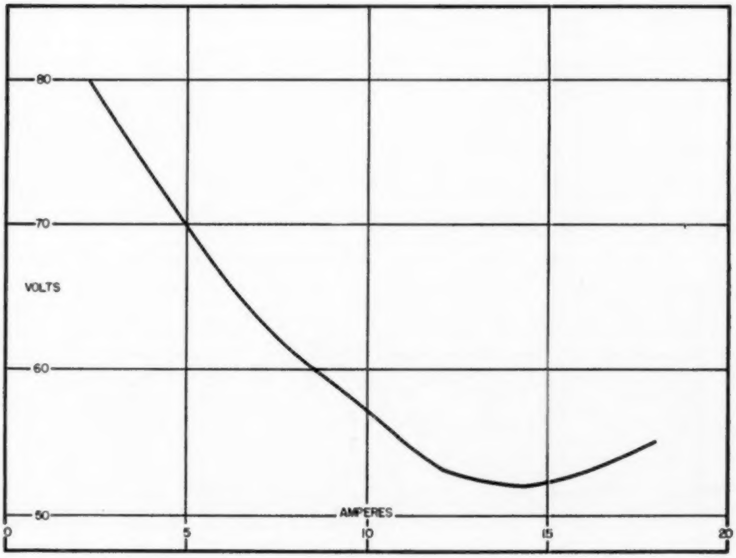


Fig. 5. Volt-ampere characteristic, 1000-w open-air concentrated-arc lamp.

The wattage versus candlepower relationship is shown in Fig. 6. At 1 kw the new lamp produces three candlepower per watt of power input.

The spatial distribution of the light from an electrode depends upon the flatness of the zirconium pool. If the electrode is operated at a low current in proportion to its size, the end of the electrode will be quite flat and the spatial light distribution will follow the cosine law. With higher currents, the electrode end becomes round and the light

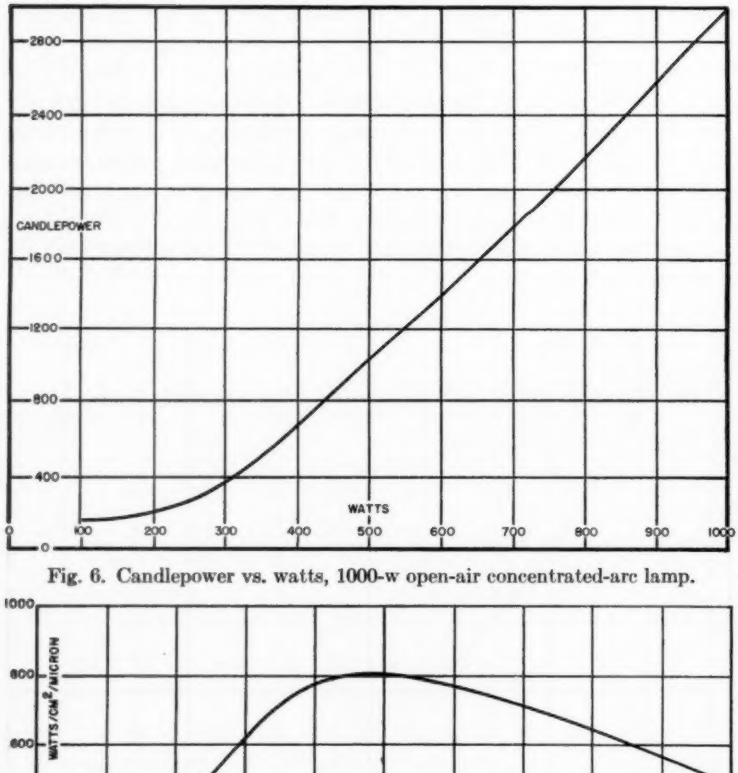


Fig. 6. Candlepower vs. watts, 1000-w open-air concentrated-arc lamp.

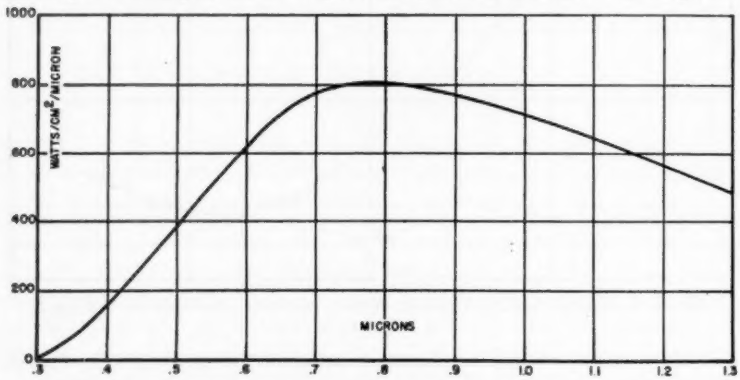


Fig. 7. Spectral energy distribution, 1000-w open-air concentrated-arc lamp.

distribution approaches that of a luminous hemisphere. Measurements show that the pool is normally only slightly rounded.

The total light output of a 1000-w lamp is about 20,000 lm (lumens). The efficiency is thus 20 lm/w. This figure compares favorably with the lumen efficiency of other light sources.

The color temperature of the light produced by the new lamp is about 3600 K (degrees Kelvin). The radiant energy has a spectral distribution in the infrared, visible and near ultraviolet as is shown in Fig. 7. This is substantially the curve of a black- or gray-body radiator peaking around 8000 A (Angstrom units). In addition to the visible light, there is a strong continuum extending far into the infrared and ultraviolet regions of the spectrum. A spectrogram of the ultraviolet radiation is given in Fig. 8. The upper of the three films is of

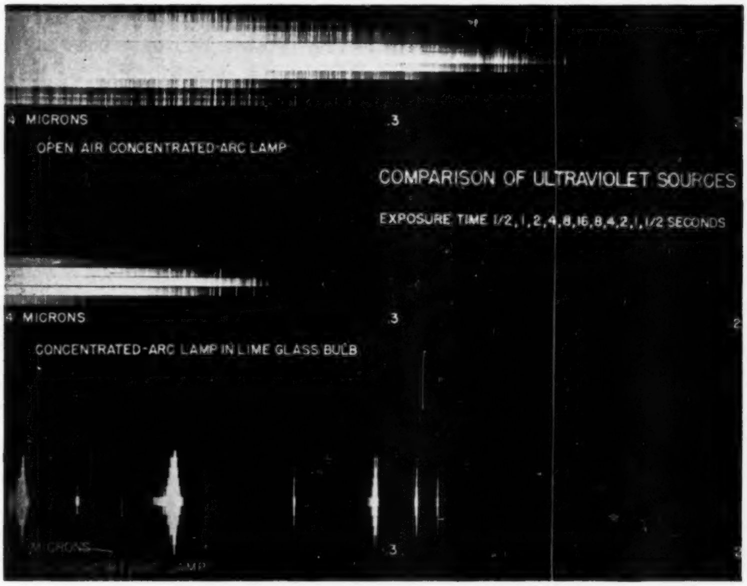


Figure 8.

the open-air concentrated-arc lamp in the spectral interval between 4000 and 2000 A. The eleven individual traces were taken at exposure times of ½, 1, 2, 4, 8, 16, 8, 4, 2, 1, and ½ sec respectively. It can be seen that the open-air arc has a strong continuum superimposed by a line spectrum which extends well toward 2000 A. Similar spectrograms of the conventional concentrated-arc lamp in a lime glass bulb and of an S4 mercury vapor lamp are given for comparison. When the new open-air lamps are operated unenclosed by glass, care must be taken by the operator to avoid sunburn and eye injury.

During the early work with electrodes operating in air from alternating current, it was thought that there would be no appreciable loss of zirconium during operation. This seemed to be confirmed by tests which showed no loss in weight but even a small gain in weight during the first few hours of burning. More extended measurements show that the electrodes first gain and then lose weight. The gain comes from the oxygen taken from the air to produce the zirconium oxide cap. After this cap is once fully formed, the weight decreases at a rate of about 0.05 gram or 0.0017 oz/hr for the ¼-in. diam. electrode burning at 650 w. This represents a reduction in the length of the electrode of about .01 in./hr. The erosion characteristic of a ¼-in. diameter electrode at various wattages is shown in Fig. 9.

This loss is due in part at least to the use of alternating current to operate the lamp. The mechanism of recapture of escaping zirconium atoms by ionization and attraction, which is so effective in the enclosed lamp, is disturbed by a-c operation. The reversing potential and the periods of zero current during the a-c cycle give greater opportunity for the escape of zirconium atoms from the region of the electrodes.

The ¼-in. diameter electrodes have a tip of active material which is about ¼-in. in length. Their life versus wattage characteristic is shown in Fig. 10. They last for about 24 hr when operating at 650 w and for about 6 hr at 1000 w. Electrodes can be made with several inches of active material. They should last for several hundred hours.

The nickel tube and the zirconium core burn down together. The length of an electrode gives a sure indication of the number of hours of use remaining in it. When the active material has been entirely consumed, the lamp goes out and new electrodes must be inserted. A new electrode forms and reaches full brilliancy during the first two minutes of operation.

It is estimated that replacement electrodes can be produced to sell at a price which will make these new lamps competitive with other types of high-intensity sources.

The rate of burning of an electrode depends upon its diameter and the number of watts applied to it. A ¼-in. diameter electrode loses .017 oz/hr at 650 w. This is an exceedingly small amount of material. The products of combustion have been judged by the U.S. Public Health Service to be nontoxic in the quantities involved and to con-

stitute no health hazard. Thus, it is expected that for most applications, the new lamp will not require special ventilation.

In the early work with this new lamp, the two electrodes were mounted end-to-end and were rotated during operation at about one revolution per minute. Such a mounting and the rotation were required to keep the arc stream well centered and to maintain the luminous spots on the ends of the electrodes. While such an end-on arrangement of the electrodes worked well in a device such as a searchlight, which employs a large mirror as the light collecting element, it is not adapted to compact optical systems using lenses.

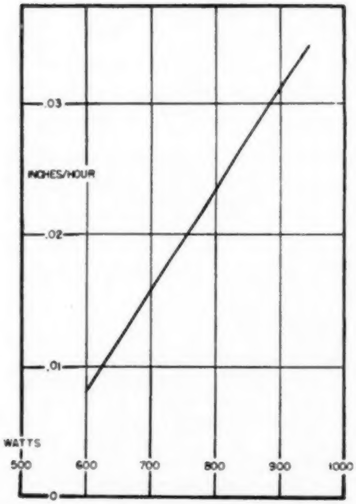


Fig. 9. Electrode erosion vs. watts, ¼-in. diam. electrode.

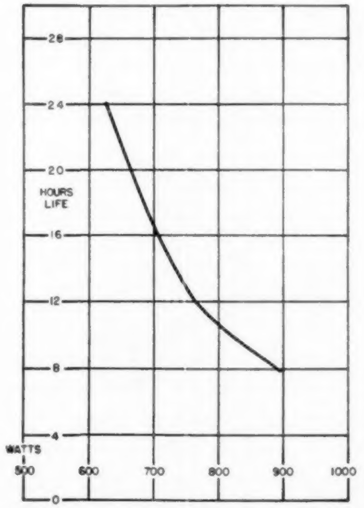


Fig. 10. Electrode life vs. watts, ¼-in. diam. electrode with core ¼ in. long.

A mounting arrangement was tried in which the electrodes were at right angles to each other, as in some carbon arcs. Such a mounting is shown in drawing A of Fig. 11. With this disposition of the electrodes, it should be possible to collect practically all of the light from either electrode with a comparatively small lens. It was found, however, that the arc tended to concentrate on the edges of the two electrodes where they were nearest together, as shown in B of Fig. 11, and produce two luminous discs whose planes were parallel and in-

clined at an angle of 45° with the axes of the electrodes. As a result, little light reached the lens.

The luminous spots could be brought to the center of the end of each electrode if the electrodes were spaced so far apart that the arc stream was carried up in an arch-shaped path by the convection currents in the air as in drawing C of Fig. 11. This arrangement was unstable, however, for with the slightest draft, the arc would either shorten and produce the parallel discs of light or lengthen and blow out.

A suitable solution to the problem was found in a magnetic control system which employs a differentially wound electromagnet which is

Fig. 11. Types of electrode and arc stream arrangements.

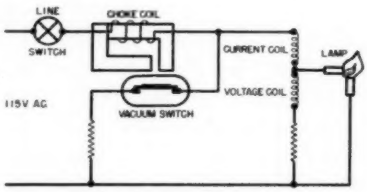


Fig. 13. Choke type of power supply.

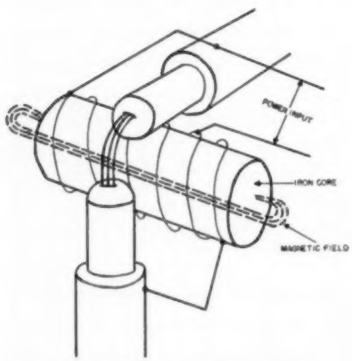


Fig. 12. Differential magnetic arc control system.

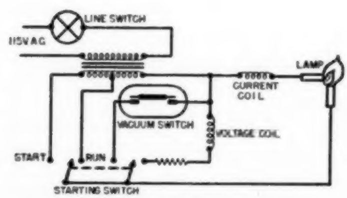


Fig. 14. Transformer type of power supply.

mounted at right angles to the two electrodes and on a line which bisects the angle between them, as shown in Fig. 12. One winding of this coil is connected so that it is in series with the electrodes. Thus, its magnetic effect is proportional to the current being drawn. It is poled so that the arc stream is deflected outward and away from the electromagnet by its reaction with the magnetic field. A second winding on the same iron core is connected across the two electrodes so that its magnetic field is proportional to the voltage across the arc and it is poled to pull the arc in toward the electromagnet.

In operation, the field of one coil tends to neutralize that of the other as long as the arc stream is in the correct position. If the arc tends to shorten, the voltage coil is weakened, the current coil is strengthened and the arc is forced out to a longer path. When the arc stream tends to become too long, the opposite action takes place and the arc is pulled back to its proper position. Thus, the arc stream is under constant automatic control. A small, permanent magnet is placed near the arc so that its field is at right angles to that of the electromagnet. This gives the arc stream lateral stability.

A lamp using this magnetic arc control system not only made it possible to operate the electrodes at right angles to each other and to obtain a good light output but also permitted the luminous spot to be held so accurately on the ends of the electrodes that rotation of the electrodes is not necessary. In addition, the arc stream is so well controlled that spacing between the electrodes becomes very noncritical. As a result, such a controlled arc can be started and, as the electrodes erode very slowly, it will operate for several hours unattended and without adjustment. The maximum length of time possible between adjustments of the electrodes depends somewhat upon the open circuit voltage of the power supply. A designer has the choice of producing a small light power supply unit with a low lamp supply voltage which may require adjustment of the electrodes of the lamps operated by it every half hour or a larger, heavier, higher voltage unit which will allow longer intervals between adjustments.

Figure 13 shows the circuit diagram of a very simple power supply unit. It consists of a choke coil and a vacuum switch combination which produces the high voltage pulse required to start the arc. The starting sequence is as follows: The two electrodes are brought together so that the zirconium oxide caps are touching and the power unit is turned on. Current flows from one side of the line through the inductor, the vacuum switch and current-limiting resistor to the other line wire. This produces a magnetic field around the choke coil which in turn lifts the armature of the vacuum switch and opens it suddenly. The resulting inductive pulse, generated in the coil, is sufficient to start a current flowing through the electrodes. Once started, the arc continues. The current is limited by the inductor. The magnetic field holds the vacuum switch in the open position.

This same type of power unit can be used to start and run the lamps on direct current if a suitable current-limiting resistor is connected in series.

A better power supply for a-c operation is shown in Fig. 14. This employs a high-leakage type transformer to send a constant current through the arc. Starting is made easier by applying about 300 v to the electrodes when the starting switch is in the "Start" position. The vacuum switch operates as before to produce the starting pulse. A 1000-w power supply unit of this type is shown together with a lamp in the photograph of Fig. 15. This power unit measures 6 × 6 × 7 in. and weighs 27 lb.

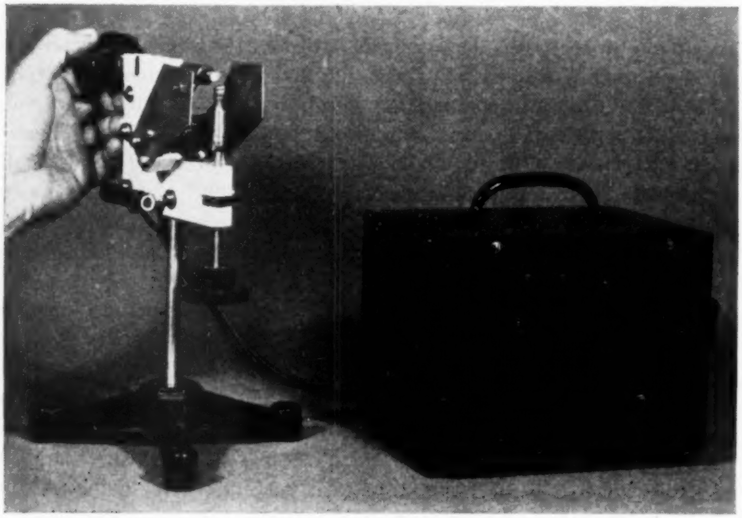


Fig. 15. Experimental 1-kw a-c open-air concentrated-arc lamp and transformer unit.

Automatic starting and electrode feed are incorporated in the unit diagramed in Fig. 16. The electrodes are mounted so that they can be brought together or drawn apart by the operation of a small two-phase motor, advancing or retracting depending upon its direction of rotation. One winding of the control motor is connected with a phase-shifting condenser in series across the 110-v a-c supply line. The voltage which is applied to the second winding of the motor is obtained from two sources. The first voltage is that across the secondary of the transformer marked A. This is a small step-up transformer whose primary is in series with the arc; thus, its secondary

voltage is proportional to the arc current. The second voltage is that across the arc. Since these two voltages are in phase they can be connected so as to oppose each other.

At the selected arc current and electrode spacing, the voltage from transformer A exactly equals the voltage across the arc and the resultant, which is applied to the motor, is zero. Thus, the motor and the electrodes are stationary.

As the electrodes erode away, the arc voltage tends to increase and the current to decrease. This upsets the voltage balance in the control circuit and causes the motor to operate in a direction to reduce the electrode spacing. If the spacing is too close, the opposite action is produced. The rate of correction is proportional to the amount of correction needed. During starting, before the arc is established, there is voltage across the electrodes but no current flowing, so the control motor operates at a high speed and brings the electrodes

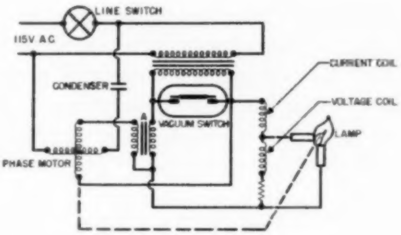


Fig. 16. Power supply with automatic control of electrodes.

together quickly. As soon as the arc is struck, the electrodes are drawn apart and maintained at their proper spacing.

With this automatic start and feed arrangement, the lamp can be operated without any attention except the periodic replacement of the electrodes which may be at intervals of several hundred hours.

The high intensity and the uniform brilliance of the luminous source of the new lamp make it particularly useful in projection applications. An optical bench has been set up, simulating the optical system in a 16-mm projector in which the light source is a 1-kw open-air concentrated arc. The condenser is a special one designed by the Fish-Schurman Co. for this type of work. A standard 16-mm film gate and a DeVry 2-in. $f/1.6$ projection lens complete the system. This combination produced a little over 2000 screen lumens. If a shutter loss of one-third is allowed, a final screen illumination of better than 1300 screen lumens is indicated.

There is no reason why larger wattage lamps cannot be built and applied to larger projection equipment. There is also the possibility of using the 300-w open-air concentrated-arc lamp in an 8-mm projector. The power supply for this size of lamp can be made cheaply from a standard 400-w mercury-vapor lamp transformer and a vacuum switch. The combination of this lamp and power supply is very simple to operate. This unit was designed particularly for laboratories where a compact and stable high intensity source of visible, infrared or ultraviolet radiation is required.

In photographic flood and spot lighting, the new lamp has the advantages of unusual stability, good lumen efficiency, small source size, a continuous spectral distribution and a high and constant color temperature.

In general, the new lamp should work well in the many applications now utilizing the low-intensity carbon arc, but with its increased stability and ease of operation, long electrode life and a-c operation it will undoubtedly be used in many places where the carbon arc would be unsuitable. It is hoped that the new Western Union Open-Air Concentrated-Arc Lamp will prove to be a valuable new tool for the solution of lighting problems.

Light Measurement For Exposure Control

By DON NORWOOD

Basic and Applied Researcher; Patent Licensor to the Director Products Corp., and Others

Summary—**This paper defines the various factors that are involved in photographic exposure control. The relationships of these factors are developed under special and general conditions. The importance of the key-light intensity and relative location of source is shown. A formula for determination of setting of camera exposure controls is developed. Practical application of the fundamentals to the design of photographic exposure meters is discussed.**

In October of 1940, I presented to the Society of Motion Picture Engineers a treatise entitled "Negative Exposure Control."[1] That paper covered some phases of exposure control matters. It also introduced an exposure meter which had been invented and developed by the author. That exposure meter was designed to measure incident light. It had a unique type of light collector in the form of a translucent hemisphere.

Since that time tens of thousands of hemisphere-type meters have been manufactured and extensively used in professional and amateur practice. Their superior qualities have been demonstrated under all types of conditions. However, the hemisphere-type meter represents only one facet of the broad project. There are parallel types of devices by means of which the basic theory may be put into practice. The general situation has now evolved to the point where the status of contingent matters, such as patent protection, makes possible the presentation of the basic theory on the subject.

This paper presents the basic theory. In line with present-day conditions, particular attention will be devoted to the matter of exposure of natural color films of the monopack type, such as Kodachrome, Ektachrome and Ansco Color. Full cognizance is given to the fact that these color films are reversal films which permit no compensating

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latitude in printing exposure. It may be noted that original exposure for such films must be much more closely controlled than for black and white films. A degree of exposure accuracy that is suitable for color films will also be quite suitable for black and white films, but the converse is not necessarily true. For these reasons the problem involved in exposure of color films will be considered in some detail.

Theory of Exposure Control

Presentation of the theory of exposure involves analysis of a photometric-photographic complex. This photometric-photographic complex is composed of a number of variables. In fact, there are so many variables that it is not advantageous to immediately include all of them as variables in the first analysis.

It has been found desirable to consider first the basic central elements. Fundamental relationships can then be developed for these basic central elements. Following this, the effects of the other variables can be considered. In this manner the relationships involving all elements can be logically developed and carefully considered.

The Special Case

Pursuant to the above, consideration will first be given to a photographic scene arrangement in which all elements of the subject are uniformly illuminated from a fixed light source adjacent to or directly behind the camera. Subject surfaces will be so oriented as to be normal to the light-to-subject axis in each case. This condition may be kept in mind during the following analysis.

The Factors Involved

It is desirable to define the factors involved. First there is the photographic subject. Photometrically speaking, the photographic subject presents a group of assorted reflectances. These reflectances may have values as low as 2%, for black velvet, and as high as 80%, for a white blotter. All other diffuse reflectances will fall between these two in value. Thus the primary concern is with a group of diffuse reflectance values extending from 2% to 80%.

Second, there is the recording medium, the film. Natural color films of the reversal type may be assumed to have an average acceptance range of about 1–40. Within that range there is one place, and one place only, for each value of subject reflectance. Since color films of the reversal type have no compensating latitude in print-

ing exposure, it follows that each value of subject reflectance must fall into its proper place at the time of first exposure.

From the above it may be noted that the natural color films have acceptance ranges which just cover the values which may be encountered in the reflectances presented by a uniformly front-lighted photographic subject.

Third, there is light, which acts as a carrier medium. Light may be said to originate in a source, such as the sun or a lighting unit. From the source the light travels to the photographic subject. From the subject the light travels on to the camera. It passes through the camera lens, past the shutter, and finally impinges on the film. The light which travels from the subject to the camera carries modifications which represent the reflectances presented by the subject.

The intensity of a ray of light which impinges on a point of that subject can be represented by E. Assume that the particular point of the subject upon which the ray impinges has a reflectance of 5%. The intensity of the reflected ray would then be

$$E \times .05 = .05E.$$

If another ray from the same source impinges upon a point of the subject having a reflectance of 70%, the intensity of that reflected ray would be

$$E \times .70 = .70E.$$

Similarly, all other reflectance values presented by the subject, may be represented.

It may be noted from the above that the light acts as a carrier to convey to the camera the reflectance values presented by the subject. It should also be noted that the same light which leaves the source and approaches the subject is that which finally impinges on the film. It has simply picked up certain modifications at the point of reflection. These modifications should be faithfully conveyed, on the carrier, to the film.

Fourth, there are the camera exposure controls. These consist of a diaphragm in the lens to modify the relative intensity of the carrier light which passes through the lens, and of a shutter to control the length of time during which the light is allowed to impinge on the film. These controls are necessary in order to secure a proper exposure of the film.

Now that the four factors involved in exposure control have been identified, it is possible to consider the relationships between the four.

RELATIONSHIPS OF THE FACTORS

It has been noted that the film-acceptance range of 1–40, and the subject-reflectance range of 1–40 are similar in value. The reflectances presented by the subject can be made to fit quite nicely into the film-acceptance range. Thus the factor *Subject Reflectances* is taken care of by the factor *Film-Acceptance Range, with each element of Subject Reflectance falling into its proper niche on the Film-Acceptance Range.*

There are two remaining factors, namely, the *Incident Light* and the *Camera Exposure Controls.* Consider the carrier, the incident light which impinges on the subject and then carries the subject reflectances to the camera. It may commonly have any one of a wide range of values. It may be as low as ¼ ft-c, or it may be as high as 12,500 ft-c. This is a very extended range, being of the order of 1–50,000. It is quite necessary that the carrier be modified to a proper fraction of its original value before it is allowed to impinge on the film. The particular value to which it must be modified depends upon the sensitivity of the film in the camera. (In accord with motion picture photography, it is convenient to think of this matter in terms of a fixed exposure time; however, the reciprocity law applies here as elsewhere.)

The modification is accomplished by the camera exposure controls. If the camera exposure controls are properly set, the carrier, which may be designated as E, will be so modified that each element of subject reflectance will be properly placed on the film acceptance range.

It is worthy of note that the four factors involved in exposure control are thus separated into two independent groups. *Subject Reflectances* are taken care of by *Film-Acceptance Range. Incident Light* (the carrier) is reduced suitably by the *Camera Exposure Controls.*

However, intelligent modification of the carrier E can be made only after said carrier E has been duly measured. A mathematical analysis of the relationships involved will indicate how the measurement may be best accomplished. The following notations will be used:

E = Incident illumination on subject (foot-candles)
B = Brightness of subject (foot-lamberts)
e = Exposure (meter-candle-seconds)
t = Time of shutter opening (seconds)
f = Relative lens aperture (f-stop numbers)
S = Sensitivity of film (ASA Index rating)
R = Reflectance of subject
I = Image illumination (meter-candles)

It may be stated that

$$B = ER \qquad \text{by definition} \qquad (1)$$

Also,

$$I = B \times \frac{4.4}{4f^2} \qquad \text{from Mees,}^{2} \qquad (2)$$

$$I = 1.1\frac{B}{f^2} \qquad \text{simplified} \qquad (3)$$

Also,

$$e = It \qquad \text{by definition} \qquad (4)$$

$$e = 1.1\frac{Bt}{f^2} \qquad \text{by substitution} \qquad (5)$$

$$e = 1.1\frac{ERt}{f^2} \qquad \text{by substitution} \qquad (6)$$

At this point it is necessary to consider the relationship of subject reflectance to print transmittance (in the case of a natural color transparency), which will give a satisfactory picture; also, in turn, the relationship of the final, positive-image transmittance to the preliminary negative opacity; and again, in turn, the relationship of the negative-image opacity to the exposure.

For the purpose of analysis, consideration will be limited to a straight-line approximation to relationship curves for the factors involved. Then, subject-reflectance values must be represented by print-transmittance values which are proportional thereto. Print-transmittance values are proportional to negative opacities. Negative opacities are proportional to exposure values. It therefore follows that exposure values must be proportional to subject-reflectance values,

$$e = k_1R \qquad \text{where } k_1 \text{ is a constant} \qquad (7)$$

The above equation contemplates the relationships for a color film having a given sensitivity. The equation may be expanded to include the said relationships for color films of any sensitivity by inclusion of the factor S. To achieve a given transmittance in the positive image, the factor e must also be inversely proportional to S.[3] Thus,

$$e = k_2\frac{R}{S} \qquad \text{where } k_2 \text{ is a constant} \qquad (8)$$

A substitution in equation 6 may now be made, to give,

$$k_2\frac{R}{S} = \frac{1.1\,ERt}{f^2} \qquad \text{by substitution} \qquad (9)$$

$$\frac{f^2}{t} = \frac{1.1\,ES}{k_2} \qquad \text{by rearrangement} \qquad (10)$$

Then let,

$$\frac{1.1}{k_2} = \frac{1}{K} \qquad \text{where } K \text{ is a constant} \qquad (11)$$

$$\frac{f^2}{t} = \frac{ES}{K} \qquad \text{by substitution in (10)} \qquad (12)$$

$$\frac{f^2}{t} = E\,\frac{S}{K} \qquad \text{by rearrangement} \qquad (13)$$

It may thus be seen that the proper setting for the *Camera Exposure Controls*, for a given film sensitivity, is a function of E, the *Incident Illumination*.

It is well to note at this point the necessity for carefully distinguishing between so-called *exposure*, and the *setting* for the *Camera Exposure Controls*. Exposure of each element of area of film is proportional to the relative brightness of the corresponding element of area of the subject. Many, many different exposure-producing values of brightness may, and usually do, simultaneously pass through one setting of the camera exposure controls. However, the setting for the camera exposure controls is not a function of any or all of these brightnesses, as has been held in some quarters. The setting for the camera exposure controls is a function of the incident illumination.

There apparently has been, in the past, a certain degree of confusion on this point. Reference to the foregoing equations should clarify the matter. Exposure of each element of area of film is proportional to the brightness of the corresponding element of area of the subject, other variables being held constant (see equation 5). The exposure value for each element of area of film must represent the particular value of reflectance of the corresponding element of area of the subject (see equation 8). Setting for the camera exposure controls is a function of the incident illumination (see equation 13).

THE GENERAL CASE

Up to this point the problem has been simplified by the assumption that the subject is uniformly illuminated by a light source located behind the camera. Now it is necessary to depart from the simplifying assumption, and consider the effects that are encountered when

the primary light source is found in other positions, and a three-dimensional subject is used. A unique problem arises at this point. This problem derives from the fact that the photographic effectiveness of the incident light changes in value as the light source changes position with respect to the camera-subject axis.

It will be appreciated that if the light source were located directly behind the camera, all parts of the camera-side of a three-dimensional photographic subject would receive illumination from that source. In such a case the photographic value of the incident light would be 100% of the intensity value. If the light source were moved around through 180° from the first position, to a position directly behind the photographic subject, no part of the camera-side of the subject would be illuminated, and the photographic value of the incident light, from that source, would be 0% of the intensity value. If the light source were located at a side position, whereby the light-subject axis formed a 90° angle to the camera-subject axis, with the subject at the apex of the angle, the illumination from the light source would fall on just one-half of the camera-side of the subject.

It is necessary to digress slightly here, and point out that under common photographic conditions there is usually a secondary light source or sources in addition to the primary source. Outdoors the sun is usually the primary light source, the sky is the secondary light source. The intensity of the illumination from the sun is normally about eight times as great as the intensity of illumination from the sky. This means that about 89% of the illumination is from the primary source, and only about 11% from the secondary source. For this reason the primary source may be considered as the controlling factor in exposure determination, and as such, is known as the key-light.

THE KEY-LIGHT

The key-light constitutes the major factor in exposure determination. The key-light establishes the high-light effects on a subject. In the case of color films the exposure must be adjusted to give proper recording for the high lights. The fill-light is useful and necessary to achieve acceptable pictures but is distinctly secondary in exposure control matters. In the case of indoor work the illumination is usually balanced as between key-light and fill-light to provide a pleasing approximation to the natural illumination found outdoors. Again the key-light is the controlling factor.

It is interesting to note the recommendation made by a prominent manufacturer of color films, with respect to exposure: "Expose for the high lights, and light the shadows."[4] This is just another way of stating that the key-light is the controlling factor in the setting of camera exposure controls for color film.

Now it is possible to return from the digression to consider the case of the intermediate positions for the key-light source. In this case the relatively strong key-light falls on just a portion of the camera-side of the subject. The relatively weak fill-light illuminates the balance of the camera-side of the subject. Under these circumstances the photographic value of the illumination is less than when the key-light source is located in the 0° position.

I have engaged in considerable research directed toward a determination of the relative illumination value when the key-light source is located in various positions relative to the observer-subject axis. A parallel problem is the determination of the relative photographic value when the key-light source is located in various positions relative to the camera-subject axis.

The problem appears to lie in two fields, namely physics and physiology. The factors which belong in the field of physics are those of light intensity and the geometrical arrangement of the light source, the subject and the observer. The reaction of the eye of the observer belongs in the field of physiology.

It appears that positive laws for the reaction of the eye are not definitely known for all conditions. It is known that the eye automatically changes its sensitivity as the effective illumination on the subject changes. The exact degree of change appears to be unknown. It was believed that a good approximation to these values for sensitivity change could be obtained by means of taking numerous pictures of a scene, under controlled conditions, while using varied settings of the camera exposure controls. It was assumed that the most pleasing and natural appearing pictures of the scene (with regard to exposure) would be those in which the camera exposure controls had most nearly simulated the action of the eye in response to different lighting conditions.

This method was used as a statistical method, and the results obtained therefrom were empirical in character.

Numerous groups of pictures were made under conditions which will be described. Each group consisted of 12 pictures of one subject. The 12 pictures in each group were made on one strip of film and de-

veloped together, thus eliminating variables which might be introduced by different emulsions or conditions of development. All exposures were made at $1/50$ second shutter time.

The illumination on the subject, for each group of pictures, consisted of a key-light, and fill-light. Illumination contrast conditions were chosen to fit a typical norm of eight to one. In the case of negative-positive black-and-white pictures, all prints received the same printing exposure. In the case of reversal color films, all pictures in each group received identical processing.

The geometrical arrangement of key-light to subject axis and camera to subject axis was varied, so that effects of the variations might be studied. In each group of 12 pictures, three each were made under conditions of straight-front lighting or 0° key-light angle, 45° key-light angle, 90° key-light angle, and 135° key-light angle.

Various lens apertures were systematically used under each condition of key-light angle. At 0° key-light angle the lens aperture for the exposure of the basic picture was derived from use of the formula shown in equation 13, after duly making measurement of incident light intensity, and taking note of the film sensitivity. The picture resulting from this exposure was placed in position #5 in the accompanying Fig. 1. The lens aperture used for this picture was labeled A_5. Additional pictures were made at the 0° key-light angle, one with $1/2$ *f*-stop smaller aperture and one with $1/2$ *f*-stop greater aperture. The resulting pictures were placed respectively in positions #1 and #9, as shown in Fig. 1. The lens apertures used for these exposures were labeled A_1 and A_9 respectively.

A picture, to fit position #6 in Fig. 1, was then made, under conditions of 45° key-light angle. In this case an increment represented by X *f*-stop was added to the basic aperture used for picture #5. Covering pictures, #2 and #10, using respectively $1/2$ *f*-stop smaller and $1/2$ *f*-stop greater lens apertures than used for #6, were made.

The same procedure was followed for the condition of 90° key-light angle, in which an increment of Y *f*-stop was added to the basic aperture A_5. The same procedure was followed for the 135° key-light angle, in which a Z *f*-stop increment was added to the basic aperture A_5.

The twelve completed pictures which constituted each group were arranged in the form shown in Fig. 1. This arrangement provided four columns of pictures in three rows. Each column represented a different condition of key-light angle. Within each column were three different exposures. It was possible to slide each column up or

down relative to the adjacent columns until the pictures across each row matched in appearance.

The groups of pictures were studied visually in order to determine values for X, Y, and Z which would give matching effects across the rows of pictures. It was not difficult to note which pictures appeared "right," and matched in appearance. These tests were carried out with a number of groups of pictures and a number of observers.

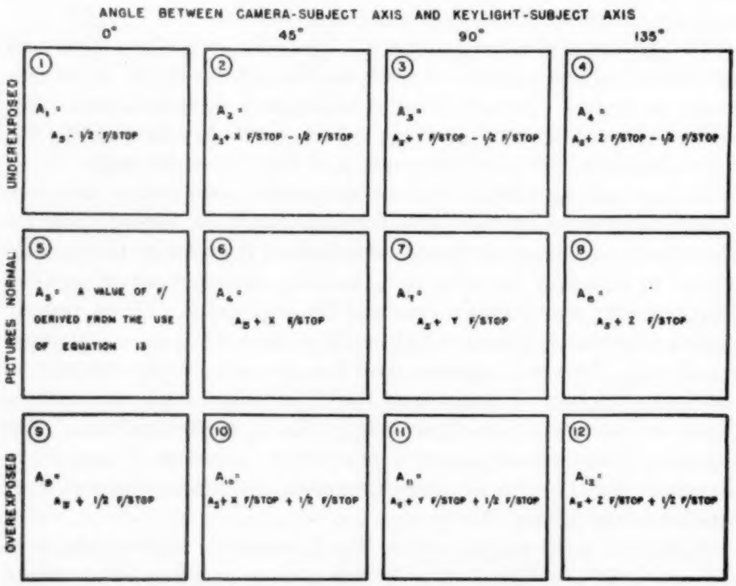

Fig. 1. Study arrangement for test pictures used for determination of relative illumination value of key-light at various key-light angles. Lens apertures designated as A_1 for picture #1, A_2 for picture #2, etc.

The statistical results obtained indicated the following optimum values for X, Y, and Z.

$$X = \tfrac{1}{2}-. \qquad Y = 1. \qquad Z = 2.$$

Translated, these values indicate the following effective values for the illumination when the key-light is located at the indicated positions.

Key-light angle:	0°	Effective illumination value:	100%
	45°		75%
	90°		50%
	135°		25%

It is rather interesting to note that these conclusions appear to be supported, at least in part, by empirical data to be found in the exposure instructions regarding front-lighted, cross-lighted, and back-lighted subjects, as issued by some film manufacturers.[5]

The foregoing data indicate that in the general case a simple measurement of key-light intensity is not sufficient to provide a complete answer for exposure control. Neither is a simple measurement of incident front-light sufficient to provide a significant value for exposure control. It is quite necessary to provide for a measurement of the intensity of the key-light, and then to provide means to modify the value so obtained by a factor which is determined by the angular location of the key-light source with respect to the camera-subject axis. Presented herewith is a chart (Fig. 2) showing a key-light source located in various positions with respect to the camera-subject axis. The modifying factor for each angle is also shown.

It is possible to organize the data in Fig. 2 into geometric form. The angle between the camera-subject axis and the subject-key-light axis is represented by θ. The modifying factor is represented by the length of ρ. The resulting curve is clearly shown (Fig. 3), and may be represented by the formula,

$$\rho = 1 - \frac{\theta}{180^\circ} \qquad (14)$$

where ρ equals the modifying factor due to the key-light angle. The effective value of the light for any key-light angle then becomes

$$\textit{Effective Illumination} = E \times \rho = E\left(1 - \frac{\theta}{180^\circ}\right). \qquad (15)$$

This concept of *Effective Illumination*, which takes into account illumination intensity, and relative positions of observer, subject, and light source, has not heretofore been crystallized or formulated; hence it may well be identified as the *Norwood Effect*. It has considerable significance in photographic work and television work as well as in certain phases of general illumination work.

The value for *Effective Illumination*, derived from equation 15, may be substituted for the simple value E in the previously derived equation 13.

$$\frac{f^2}{t} = \frac{SE\,(1 - \theta/180^\circ)}{K} \qquad (16)$$

This gives a formula for the general case, which takes care of the key-

light source in any position. This formula for the general case shows rather plainly that *the setting for the camera exposure controls is a function of the effective value of the illumination.*

An exposure meter is a device whose ultimate purpose is to indicate the proper setting for the Camera Exposure Controls. It then follows

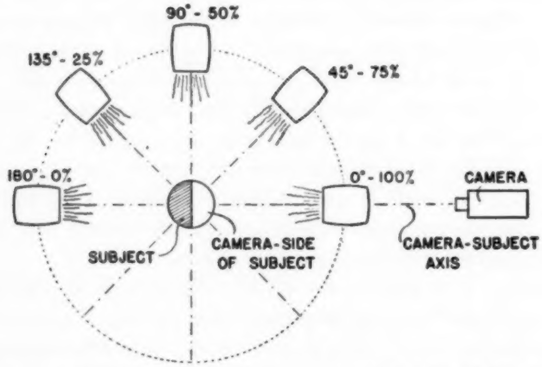

Fig. 2. Photographic arrangement, showing a key-light source located in several test positions. Relative photographic value of light for each angular location of light source is indicated.

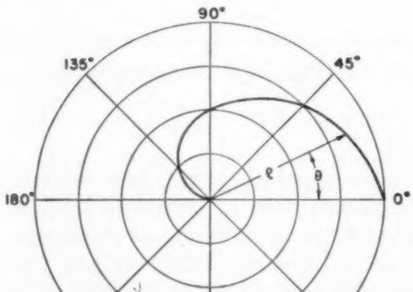

Fig. 3. Polar co-ordinate curve showing relationship between key-light angle and the modifying factor for the relative photographic value of the light.

from the above that an exposure meter should be designed to evaluate the *Effective Illumination.*

An adequate exposure meter must be provided with means for measuring the intensity of the incident light and means for taking into account the angular effect of the key-light source position.

For the constant K, in the above formula, a value of from 26–30 may be used. This figure has been determined empirically. The exact value will depend upon the density of image desired for any given purpose, such as projection through a high-powered projector, projection through a moderate-powered projector or for duplication, etc.

In the derivation of a correct exposure formula, a primary concern has been with those areas of the subject which will carry the high lights. This is in line with the premise that, in the case of color films, exposures should be determined primarily to produce appropriate representation of the high-light areas. Experimental results have confirmed the validity of the premise.

There is a terminal limitation on the key-light angle. In the case of common photography both primary and secondary light sources are usually present. Under these conditions, should the angle between the subject to primary-light-source axis and the subject-camera axis be greater than 135°, the primary light should no longer be considered as the key-light, or control light. It becomes simply a line-light in effect. The secondary light takes control over exposure controls. The center of the secondary light source would then be considered as the key-light source position.

Based upon the fundamental equation 16, various exposure meters have been designed and constructed.

THE HEMISPHERE METER

One exposure meter is that instrument which uses a translucent hemisphere for a light-collector in front of the photovoltaic cell (see Fig. 4). In use, this instrument is placed at the location of the photographic subject, and so oriented that the axis of the hemisphere lies along the subject-camera axis. When so positioned, the instrument acts to measure simultaneously the intensity of the incident key-light, and modify the intensity reading by the angular location factor of the key-light source.

The hemispherical light-collector accomplishes this dual function in the following manner: With a 0° key-light, the illumination will fall on all parts of the hemisphere and a reading of 100% of the intensity value will be obtained. With a 90° key-light, only one-half of the hemisphere will be illuminated by the key-light. It follows that a correct 50% downward modification of the intensity value is obtained. Similarly, with a 45° key-light, a 25% downward modification is achieved. With a 135° key-light, a 75% downward modification is achieved.

The end result is that whatever the intensity of the key-light, and whatever the angular location of the key-light source may be, the hemisphere-type incident light meter correctly evaluates both factors and gives an answer which results in a correct exposure for the conditions prevailing.

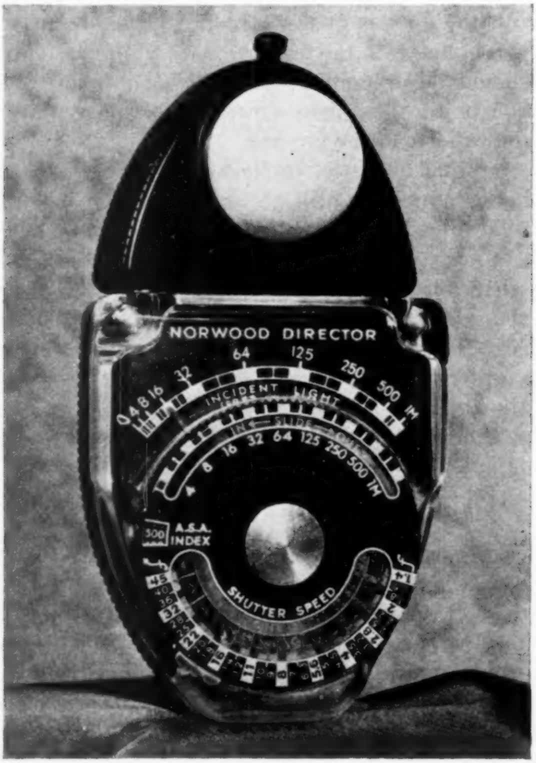

Fig. 4. Exposure meter designed around hemisphere light-collector.

A comprehension of the underlying principles involved, as presented within this paper, will show why the hemisphere-shaped light collector functions perfectly for the purpose. Light collectors of odd shapes, fitted to exposure meters, and designed to be aimed at camera location from subject position, may function in a limited manner. They may operate under conditions of 0° key-light and/or 45° key-light.

Usually however, they fail rather badly under conditions of 90° key-light, and are even more misleading under conditions of 135° key-light. Only the hemisphere form takes care of all these conditions.

THE KEYLITE METER

However, another exposure meter has been designed and built upon the basic foundation presented herein. This is an instrument known as the Keylite meter. This instrument is built with a light collector which is only slightly curved. In operation, it is always pointed at the

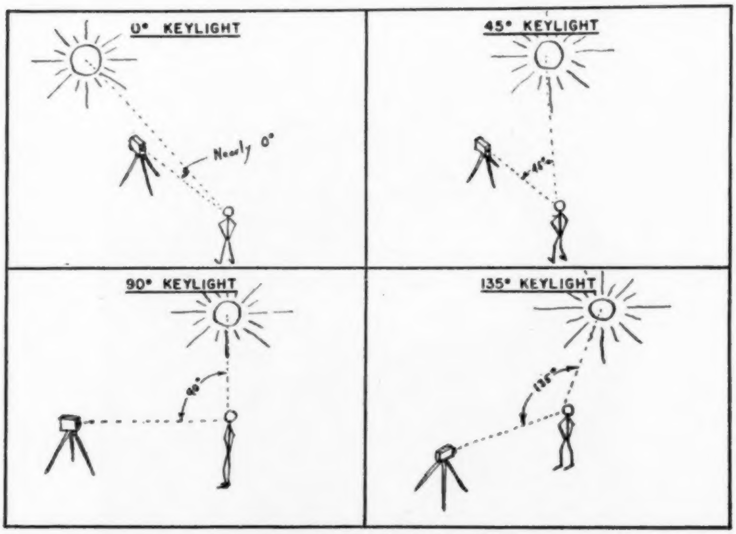

Fig. 5. Chart illustrating the four basic key-light source positions.

key-light source. The primary reading so obtained is that of key-light intensity. The intensity reading so obtained is used directly on a computer device. The computer device has scales which take into account key-light intensity, key-light angle and film sensitivity, and give significant readings for camera lens aperture and shutter time.

The key-light angle is estimated by the operator. In practical work it is only necessary to classify the key-light source as being in one of four broad location groups. The groups include: 0° angle, 45° angle, 90° angle, and 135° angle (see Fig. 5). This classification is rather easily accomplished by the operator.

There are certain very desirable features inherent in the Keylite-type of meter. It is a meter that provides most efficient use of cell and microammeter, since the light collector is pointed directly at the source of illumination. In this manner greatest sensitivity is achieved. It is a satisfying type of meter to operate since it is a maximum-reading type of instrument. That is to say, the operator may point the instrument at different angles until the maximum pointer deflection is noted. The maximum reading is the significant reading. To most operators this feature is rather gratifying because it gives a sense of security in having obtained the absolutely correct reading.

Fig. 6. Exposure meter designed to measure the key-light.

It is probably unnecessary to point out that there are other types of exposure meters which may leave the operator quite uncertain, since relatively small changes in angular position of the meter may produce large changes in readings, and the operator has no sure guide as to which reading has significance.

The Keylite-type of meter has great versatility. It may be used at the position of the subject for indoor pictures. For outdoor pictures it may be used at the position of the subject if desired, or, since out-

door illumination is usually quite uniform over extended areas, it may be used at the position of the camera, or any other place where the illumination is the same as that on the subject.

Due to the fact that the meter is equipped with a light collector which has an acceptance angle of near 2π steradians, the meter may be usefully employed to measure both key-light intensity and then fill-light intensity. A comparison of the two values will serve to indi-

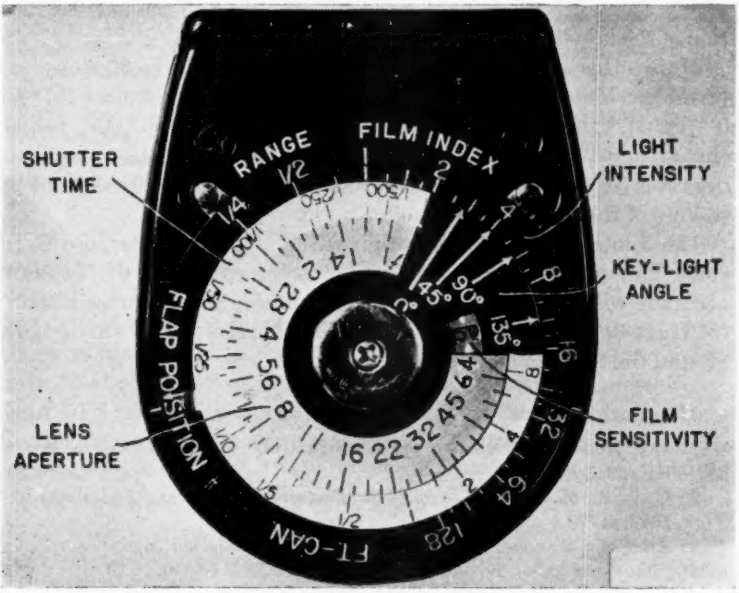

Fig. 7. Special computer designed to solve equation 16.

cate the illumination contrast. This factor is quite useful in the case of color films. It is also significant in the case of black-and-white films, where uniform light balance in a series of scenes is desired.

Figure 6 shows the Keylite meter. The instrument is quite compact. The scale is clear and simple, being calibrated directly in foot-candles. An exponential type of scale is used because of its suitability for photographic work. The scale covers two ranges, namely, 0–128 ft-c and 0–12,800 ft-c. These two ranges provide accurate readings

from ¼ to 12,800 ft-c, which covers all general photography. A hinged range-changer mask is provided to fit over the cell.

The special computer is shown in Fig. 7. The computer is designed to solve formula 16 which takes into account the *Norwood Effect* for illumination,

$$\frac{f^2}{t} = \frac{SE\,(1 - \theta/180^\circ)}{30}$$

This computer is unique in that it incorporates a scale to modify the value of any given key-light intensity according to the angular location of the key-light source.

Many other arrangements of the various scales of the computer are possible. It is also possible to substitute the words "front-light" for 0° (light), "three-quarter light" for 45° (light), "cross-light" for 90° (light), and "back-light" for 135° (light). Such variations might be desirable for some purposes. They all follow the same principle of the solving of the equation shown above.

The solution of this equation gives the most perfect exposures for color film yet achieved. As previously mentioned, the exposure accuracy which is satisfactory for color films is also quite satisfactory for black-and-white films. The exposure meters which are designed around the formula are thus very useful devices.

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A Survey of High-Speed Motion Picture Photography

A High-Speed Photography Subcommittee Report

By KENNETH SHAFTAN

Consulting Engineer, New York, N.Y.

Summary—**A survey of high-speed motion picture practices was conducted by the Society in 1949. The data collected are presented here, with a review of comments submitted by users of high-speed techniques and equipment. Conclusions are drawn by the author regarding the current availability of such information and also the scope of the survey is commented upon. Recommendations are made concerning the future of photographic instrumentation and the role of the Society in this expanding field.**

In March, 1949, the Society's High-Speed Photography Subcommittee on Requirements prepared and submitted to 150 selected recipients, a questionnaire on equipment and techniques now employed in this field. In preparing the questionnaire, primary consideration was given to the commercially available cameras in the United States because of their general use in a variety of applications. Users were asked to comment on the value of results obtained, and on the future development of suggested cameras, camera accessories and related equipment.

Recipients were selected by the Committee on a basis of knowledge and experience, from a list of known users of equipment. The amount of data requested from each was limited purposely by "brief answer" questions; however, many volunteered additional information, all of which has been included in this report.

Two months after the survey was begun, a summary report was prepared for the committee to study. Although incomplete, that summary presented an encouraging picture. The Committee felt generally that further work would be rewarding and the author was requested to prepare this complete report analyzing at length the information taken from 100 questionnaires. This represents a 67% return and includes data from six replies only partially completed because of lack of equipment or knowledge on the part of the organizations or present representatives.

Presented: October 12, 1949, as a tentative report at the SMPE Convention in Hollywood.

ORGANIZATIONS REPORTING

Table 1 classifies by type the organizations reporting; and Table 2 presents users who are in the industrial category, the largest single group.

Table 1. General Types of Users

Type	No.	%
Universities, research foundations, hospital research groups.....	19	20.2
Industrial..	60	63.8
Governmental agencies (12 of these are military and naval)....	15	16.0

Table 2. Industrial Group Breakdown

Business	No.	Business	No.
Aircraft	11	Food products	1
Electrical equipment	9	Food handling machinery	1
Light and heavy machinery	7	Industrial burner	1
Industrial research laboratories	6	Petroleum	1
Automotive and automotive accessory	4	Camera manufacture	1
Business machine	3	Railroad	1
Arms and ammunition	2	Steel fabrication and manufacture	1
Textile machinery	2	Drinking cup manufacture	1
Valve	1	Vacuum cleaner	1
Soap	1	Chemical	1
Paint spray equipment	1	Ball bearings	1
Can manufacture	1	Cork products	1

In the author's opinion, returns were large enough and sufficiently representative to serve as the basis for numerous useful conclusions.

Although the questionnaire did not inquire about the frequency of camera use or the quantity of film consumed per camera per month, considerably greater footage is generally used by governmental agencies than by commercial researchers. Specific amounts or ratios are not available nor are these figures felt to be particularly significant in the present study.

The contributed data are presented here with the author's accompanying discussion and are arranged by subject rather than in the order of the questionnaire.

CAMERAS

Of the 273 cameras listed in Table 3, there are 240 which may be classed as high-speed. The General Radio cameras are dual purpose;

they may be used for either image- or non-image-forming photography. There were 30 cameras designed primarily for the recording of oscilloscope traces, while two others are not considered as high speed, for their maximum frame frequencies do not exceed 180 frames/sec. In all the succeeding information, however, all cameras and their accessory equipments will be included.

Table 3. Types of Cameras

Designation	No.	Designation	No.
ERPI	5	DuMont-Fairchild Oscillo-Record Camera	15
Eastman High-Speed Camera, Type II	2	Naval Ordnance Laboratory Oscilloscope 6-Trace Camera	12
Eastman High-Speed Camera, Type III	74	White Engineering	3
Kodak High-Speed Camera	3	Bowen-Knapp Ribbon Frame Camera	1
Western Electric Fastax 8-mm	37	Bell & Howell 70-G (125 frame/sec)	1
Western Electric Fastax 16-mm	68	Unknown	1
Western Electric Fastax 35-mm	19	*Total*	273
General Radio Company	28		
NACA 40,000 frame/sec Camera	3		
NACA 400,000 frame/sec Camera	1		

Table 4. Distribution of Cameras Among Users

No. cameras per user	No. users	Total cameras	No. cameras per user	No. users	Total cameras
1	71	71	8	1	8
2	9	18	9	1	9
3	3	9	12	1	12
4	4	16	14	1	14
5	3	15	46	1	46
6	1	6	49	1	49
			Totals	97	273

From Table 4, it is important to note that, although many users had only 1 to 5 cameras, 7 users (government agencies, chiefly military) had among them 146 cameras or 53% of the total.

SUBJECTS PHOTOGRAPHED

The variety of subjects photographed is shown in Table 5. Because of the limiting nature of questionnaires, it was not possible to ascertain what percentage of use is quantitative photography for establishing numerical data as opposed to that used qualitatively, or for visual examination only. For the time being, therefore, a number of ques-

tions will have to go unanswered. It may be seen that those reporting make the largest use of high-speed photography in:

(1) mechanical equipment study and analysis,
(2) electrical phenomena and equipment study,
(3) ordnance studies (including ballistics), and
(4) combustion phenomena research.

Table 5. Subjects Photographed

Subject	No.	Subject	No.
Aerial camera shutters	1	Mechanical equipment	47
Aircraft and aircraft components	8	Medical, aero medical research	1
Automotive mechanisms	1	Medical, vocal cords of humans before and after surgery	1
Ballistic phenomena (including underwater)	7	Milking operations	1
Capillary action (in a centrifuge)	1	Nozzle action	1
Cathode ray oscillograph recording	8	Ordnance, including guided missiles and rockets	14
Chemical reactions	2	Paint spray guns	1
Chronograph recording	1	Parachute testing	1
Cloud phenomena	1	Production machinery, metals	7
Combustion phenomena	11	Schlieren photography, high-speed	2
Compressors	1	Soap film formation	1
Electrical phenomena and equipment	16	Strength of materials, including drop tests, dynamic tensile tests, fracture of materials, stress analysis	7
Explosion phenomena	7	Surface tension phenomena	1
Fluid mechanics, gas	3	Textile machinery	3
Fluid mechanics, liquid	5	Valves and valve springs	1
Food handling and processing equipment	1	Vibration studies	2
Hydraulic equipment	1	Washing action	1
Industrial research	3	Wind tunnel tests	3
Instrument and meter recording	3		
Internal combustion engines	1		

LENSES AND FIELD SIZES

Table 6 shows the lenses currently in use. Six users did not report on lenses and 3 users merely noted that they have a number of lenses of from 25-mm to 15-in. focal length. It must be remembered that most of these lenses are used with the Eastman Kodak, Fastax and General Radio cameras.

Lenses furnished as standard equipment with the Eastman and Fastax cameras make up the bulk of those reported. The longer and shorter focal length lenses are specially mounted to fit these cameras by the user, depending upon his particular needs. Several users report the use of supplementary lenses for close-up work. A number of comments were included in the returned questionnaires:

Table 6. Types of Lenses Used

Manufacturer	Focal length mm	Focal length in.	Aperture (f/no.)	No.
Wollensak	35		$f/2$	18
	50		$f/2$	10
		2	$f/1.55$	2
		2	$f/2$	51
	101		$f/2$	2
	105		$f/3.5$	8
		6	$f/4.5$	3
	25		$f/2.7$	1
		1	$f/1.5$	1
	35		$f/3.5$	1
	50		$f/1.5$	1
	75		$f/3.5$	1
		3	$f/3.5$	1
		4	$f/3.5$	1
	150		$f/3.5$	1
		6	$f/5.6$	1
	250		$f/4.5$	1
		10	$f/4.5$	1
Eastman Kodak	25		$f/1.9$	2
		1½	$f/2$	4
		2	$f/2.7$	2
		2½	$f/2.7$	3
	63		$f/2.7$	29
		4	$f/2.7$	2
	102		$f/2.7$	8
	50		$f/1.6$	1
		6	$f/4.5$	1
Bausch & Lomb	16		$f/4.5$	1
	25		$f/2.8$	1
	32		$f/4.5$	1
		1½	$f/2.7$	1
	48		$f/4.5$	1
	50		$f/3.5$	1
		2	$f/1.5$	1
		2	$f/4.5$	1
	72		$f/4.5$	1
	75		$f/2.3$	1
	112		$f/4.5$	1
	152		$f/2.7$	1
Zeiss	50		$f/1.5$	1
Hugo Meyer		2	$f/1.5$	1
Taylor, Hobson & Cooke	47		$f/2$	1
		3	$f/1.5$	1
		6	$f/4.5$	1
Goertz		4	$f/1.8$	1
		10	$f/4.5$	1
Total				176

(1) Additional lenses should be available for the Eastman Kodak High-Speed Cameras, Type III.

(2) Present focusing devices were reported inadequate and inaccurate, indicating a need for further study and solution.

(3) Lenses of shorter focal length should be available for both Eastman and Fastax high-speed cameras.

(4) Faster lenses were requested. Reference was made to the $f/0.6$ lens recently described by Kaprelian of the U. S. Army Signal Corps.

Table 7. Number of Different Lenses per User

No. lenses	No. users	% of users	No. lenses	No. users	% of users
1	49	51	5	4	4
2	24	25	More than 5	7	7
3	11	11			
4	2	2			

Table 8. Lens Distribution by Focal Length

Focal length mm	Focal length in.	No.	%	Focal length mm	Focal length in.	No.	%
16		1	0.6	75	3	4	2.2
25	1	5	2.8	101	4	14	7.9
32		1	0.6	105		8	4.5
35	1½	24	13.6	112		1	0.6
48		2	1.1	152	6	8	4.5
50	2	72	40.7	254	10	3	1.7
63	2½	32	18.0	381	15	1	0.6
72		1	0.6				

Table 7 shows the number of different lenses available to each user. Tables 8, 9 and 10 cover focal lengths, and field widths and ranges. It may be seen that 35-, 50- and 63-mm (*i.e.*, the standard lenses) comprise 72.3% of those employed.

Field sizes ranging from 1 mm to 500 ft in width were reported. A mean field width smaller than 24 in. obtains in 86% of the photography; smaller than 13 in. in 68%; and smaller than 7 in. in 37%.

While field widths are dictated by the subject matter, it is indicated that lenses, in some instances, have limited the field widths and ranges possible. For instance, users of very small field sizes reported the regular use of supplementary lenses and therefore implied a requirement for somewhat shorter focal length lenses.

To aid in evaluating the range of field widths, the ratio (R) has been employed as follows:

$$R = \text{Field Width Maximum} / \text{Field Width Minimum}.$$

R is shown in Table 10 which covers two-thirds of those reporting, the remaining one-third having reported only in terms of average field size. Field width ranges were generally moderate but these extremes were reported: (1) 1 ft to 400 ft (R = 400); (2) ½ in. to 50 ft (R = 1200) and (3) 1 mm to 30 ft (R = 9000). An R of only 15 or less obtains for 73% of the practice because no greater range was desired or because the range was so limited by available lenses.

Table 9. Mean Field Widths

Mean field width, in.	Frequency	Mean field width, in.	Mean field width, ft	Frequency	Mean field width, ft	Frequency
¾	1	11		1	7½	1
1	2	12		10	8	2
2	4	13		1	9	1
3	3	14		2	12	1
3½	4	15		2	15	1
4	3	17		1	20	2
5	2	18		5	25	1
6	10	24		5	30	1
7	4	28		2	40	1
8	2	36		3	50	2
9	3				75	1
10	2		3½	1	200	1
			6	1	260	1

Table 10. Field Width Ranges

R	Frequency	R	Frequency	R	Frequency	R	Frequency
1.3	1	4.0	1	14	1	42	1
1.5	1	5.0	5	15	1	50	1
1.75	1	6.0	7	24	1	300	1
2.0	5	8.0	1	33.3	1	384	1
2.5	2	8.8	1	36	1	400	1
3.0	3	12.0	3	40	2	1200	1
						9000	1

From Table 11 it may be noted that 75.3% of the apertures were $f/4.5$ or larger; thus, the depth of focus is at a minimum. It is also significant that many report the use of lens apertures in the wide-

Table 11. Lens Apertures Most Frequently Used

f/No.	No.	%	f/No.	No.	%
1.5	5	2.4	5.6	27	12.9
2.0	37	17.6	8.0	13	6.2
2.7	44	21.0	11	8	3.8
3.5	33	15.7	16	3	1.4
4.5	39	18.6	22	1	0.4

open position. Those using smaller than $f/8$ were, in large measure, photographing subjects under daylight illumination at relatively low frame frequencies. The lens aperture used is dependent upon the illumination available, the frame frequency, the exposure duration per frame, the film characteristics, the depth of focus requirements, and other factors, any of which may be seriously limiting. These data indicate indirectly that one of the major problems in high-speed photography is that of providing sufficient illumination intensities.

ILLUMINATION AND ILLUMINANTS

Since the questionnaire did not cite self-luminous subjects, it may be inferred that their use is somewhat greater than the 5% shown in Table 12. Several reported supplementing daylight with artificial lights, and one reported supplementary artificial illumination of a self-luminous subject.

Table 12. Illumination Used

Type	%
Artificial light	80
Daylight	15
Self-luminous subjects	5

Table 13. Types of Illuminants

Type	No.	%
Incandescent	139	86.0
Self-luminous	8	4.9
Chemical (flash bulbs)	6	3.7
Carbon arc	5	3.0
Gaseous discharge lamps	4	2.4

Illuminants are analyzed in several ways in Tables 13–16. Of those users who had only one lighting method available (Table 15), 70% (or 40% of the total users, 38 in number) reported the use of RPS 2, RFL 2, or 750R lamps.

Several reported using no reflectors or improvising with white cardboard or blotting paper.

Because each subject photographed presents an individual lighting problem, it would not be feasible to try to report on: number of light

Table 14. Illuminants Used

Designation	Mfr.	No.	Designation	Mfr.	No.
RSP 2	G.E., Westing.	36	150/PAR/3SP	G.E., Westing.	2
RFL 2	G.E., Westing.	26	Zirconium Arc	Western Union	2
#4 Photofloods		18	500-w Photospots	G.E., Westing.	2
2000-w spots, T48, G 48CP		16	#3 bulbs	Wabash	2
150/PAR/SP (overvolted)		10	RSP 2 (over-volted)	G.E., Westing.	2
750-w spots, T24/14	G.E.	9	1500-w		1
750 R (High-speed Photo)		6	750-w T 20		1
5 kw, G 64		5	150/PAR/FL		1
Stroboscopic	G.E., G.R., etc.	4	10-kw G 96		1
Carbon arcs	Various	4	Auxiliary Field Lighting gear	Military eqpt.	1
1000-w T 20	G.E.	3	Lester Speed Lites	H. M. Lester	1
#2 Photofloods	G.E., Westing.	3	100-w, 6-v	Unknown	1
#31 Flash bulbs	G.E., Sylvania	3	Aircraft searchlight	Military eqpt.	1

Table 15. Number of Lighting Methods per User

	Frequency	%
Only one lighting method available	54	57.0
More than one lighting method available	33	34.5
Self-luminous subjects only	8	8.5

Table 16. Reflectors Used

Type	No.	Type	No.
Built-into lamps	48	10-in. spherical, Bausch & Lomb	2
Mole-Richardson Solarspots	10	Johnson Ventlites	2
Bardwell & McAllister Kegs and 2000-w	8	6-in. Parabolic, 50-in. F.L.	2
Victor 18 in.	6	Searchlight	1
Rosslites 201 and 241	5	Auxiliary field lighting gear, U.S.A.F.	1
Eastman Kodak	4	Lester Speed Lite	1
Special	4	Bantam	1
Elliptical, aluminum, 3-ft F.L.	2	Kliegl	1
Theater carbon arc projector reflector	2	Oleson	1

sources; brightnesses; spectral distribution; the use of reflectors, diffusers and back-lighting; and other practices.

This survey has borne out experience that lighting continues to be one of the most critical fields requiring attention. We should note that 57% of those reporting had available only a single illuminant,

usually a reflector spot or flood. This undoubtedly accounts for much of today's high-speed photography which is of poor pictorial quality.

LIGHT MEASUREMENT

Of the 46% reporting the use of a light meter (Table 17) at least for an estimation of the illumination, many indicated that they also relied upon previous exposure data and otherwise resorted to experience. A number have modified their exposure meters for use under high-speed photographic conditions. For the types of light meters used, see Table 18.

Table 17. Light Measurement Methods

Method	No.	%
Experience	49	51
Meters	45	46
No answer	3	3

Table 19. Interest in Proposed Light Meter for High-Speed Photography

Reaction	No.	%
Interested	72	75.0
Not interested	18	18.7
Undecided	4	4.2
No answer	2	2.1

Table 18. Light Meters Used

Type	No.
Weston	21
General Electric	11
Norwood	4
Own design	2
S.E.I.	1
General Radio 1501A	1
Type not given	14

Table 20. Types of Film Used

Designation	Mfr.	Frequency	%
Super XX Negative	Eastman	84	68.0
Super XX Reversal	Eastman	12	9.7
Kodachrome, Type A	Eastman	9	7.2
Super X	Eastman	7	5.5
Linagraph Pan	Eastman	6	4.8
Triple S Pan Reversal	Ansco	3	2.4
Panatomic	Eastman	1	0.8
Gold Seal	DuPont	1	0.8
301 A Panchromatic	DuPont	1	0.8

The 51% who reported that they resorted to experience exclusively for determination of proper exposure and illumination conditions employed test strips, manufacturers' recommendations, calculations, previous exposure data and, as one put it, an "educated guess."

There was significant response to a question about the need for a high-speed photography light meter of the barrier-layer cell (Table 19). Several felt that a new meter should be reasonably priced, should measure incident-light, should be balanced for the color temperature

of *photofloods* and compensated for reciprocity-law failure and other factors which become critical in high-speed photography.

A few felt that their experience, their satisfaction with self-modified light meters, or an insufficient use of high-speed photography would preclude their interest in the proposed meter. Users of the S.E.I. and General Radio 1501A meters felt that they were entirely satisfactory. One user indicated that a light meter for his particular application, flame-propagation phenomena, could not be made.

It is understood that Weston Electrical Instrument Corp. has developed the proposed light meter and designated it Weston Model 757.[1]

FILM

Since the fastest film normally available for high-speed photography is used in a majority of applications (Table 20), we are justified in assuming that adequate lighting has been found difficult to achieve.

Several recommended the development of black-and-white and color emulsions with increased exposure index characteristics and of new emulsions with extended spectral range and sensitivity to radiation ranging from gamma rays to the far infra-red. In discussions, it was learned that the major film manufacturers are busily engaged in pursuing these goals. A startling increase in emulsion speed is not in the offing; but a slow, steady increase is anticipated.

A number reported requirements for a finer-grained film of higher speed. The characteristics of *fine-grain* and *high-speed* are, for a silver halide emulsion, contradictory since, in general, the faster the film, the coarser the grain. Some users reported preference for the slower, finer-grained films currently available. The reported need for finer-grained films is felt to indicate:

(1) that processing techniques employed have resulted in granularity and grain size increase greater than the optimum for the given emulsion, and

(2) that the users may be erroneously interpreting the relatively poor resolution of their high-speed records as being limited by emulsion characteristics of the film.

In discussing this second point it is desirable to point out that the fastest film generally employed for high-speed photography, Super XX Panchromatic Negative Safety Film, is reported by the manufacturer to have a resolving power of 90 lines/mm when developed in

[1] E. T. Higgons, "Exposure meter for high-speed photography," *Jour. SMPE*, vol. 53, pp. 545–548; November, 1949.

Kodak SD-21. The optical systems of both the Eastman Kodak and the Fastax cameras have much lower resolving power. Alan A. Cook of Wollensak gives the resolution for a Fastax 16-mm camera at *f*/2 (the writer assumes that Cook refers to the use of a 51-mm, *f*/2 lens) as 28 lines/mm in the corners of the image, with an increase to 40 lines/mm at the center of the picture area. He states that at *f*/3.5, 40 lines/mm are resolved over the whole picture area and that these results applied to both Super XX and to Kodachrome.[2] He does not describe the conditions under which these results were obtained.

A number reported that time delays and other difficulties in getting film processed and printed commercially had forced them to develop negative stock, in many cases in makeshift apparatus. They often view the record in that form. A requirement is reported for rapid, portable, foolproof and reliable developing equipment and procedures for both negative and reversal stock, with provision incorporated for overdevelopment where necessary.

One user suggested improvement in film storage qualities but gave no further details.

Frame Frequencies

Use of frame frequencies from 100 to 500,000 per sec (NACA 400,000 frame/sec Camera) as reported is presented in Table 21. Mean values have been used for frame frequencies in cases where they were reported as ranges rather than specific rates.

In general, the most used frame frequencies appear to lie intermediate in the Eastman and Fastax camera ranges, although many users reported using the entire frame frequency range.

Those reporting a need for increased frame frequencies are shown in Table 22, and in Table 23 are shown the frame frequencies desired.

The author is responsible for the range classifications which have not been considered generally for adoption and are at variance with another system of classification as adopted by the committee at large and reported upon by Sandell.[3]

In the study of very high-speed transient phenomena, there is an urgent need for frame frequencies higher than those presently possible with the commercially available cameras.

Those who reported a need for frame frequencies to 10,000/sec

[2] Alan A. Cook, "Lenses for high-speed motion picture cameras," *Jour. SMPE*, vol. 52, pp. 110–115 of Part II; March, 1949.

[3] Maynard L. Sandell, "What is high-speed photography?" *Jour. SMPE*, vol. 52, pp. 5–7 of Part II; March, 1949.

were, in general, users of the Eastman and the 35-mm Fastax cameras. A number of other users felt that higher frame frequencies would not be particularly useful without an accompanying marked increase in resolution.

Table 21. Frame Frequencies Generally Used

Frames/sec	No.	Frames/sec	No.	Frames/sec	No.
750	4	3,500	2	7,500	1
1,000	7	4,000	9	8,000	2
1,500	5	4,500	5	10,000	1
2,000	15	5,000	7	40,000	1
2,500	16	6,000	6	500,000	1
3,000	15	7,000	1		

Table 22. Need for Increased Frame Frequency

Reaction	No.	%
Need increase	41	41.8
Not needed at present	5	5.1
No increase needed	50	51.0
No answer	2	2.1

Table 23. Frame Frequency Ranges Desired

Frame Frequency Range	No.	%
High-speed (275 to 20,000 fr/sec)		
to 10,000 fr/sec	7	16.2
10,000 to 20,000 fr/sec	9	20.9
Very high-speed (20,000 to 500,000 fr/sec)		
20,000 to 50,000 fr/sec	6	13.9
50,000 to 100,000 fr/sec	7	16.2
100,000 to 500,000 fr/sec	1	2.3
Ultra high-speed (greater than 500,000 fr/sec)		
10^6 and faster	1	2.3
Did not know as yet	12	28.2

Interestingly enough, a relatively large number of users reported need for cameras with good operating and photographic characteristics in the lower frequency range of 100 to 500 frames/sec, below normal for the Eastman and the Fastax cameras. It is understood, however, that the 8-mm Fastax camera is rated to operate at a minimum frequency of 300 frames/sec, the 16-mm Fastax at a minimum frequency of 150 frames/sec; and that the Eastman Kodak High-Speed camera may be specially furnished to cover this desired range.

FILM CAPACITY

Table 24 shows that present film capacity is adequate for most needs. It was interesting to find that many felt that the present 100-ft film capacity was much too great. By inference, those whose use is quantitative find that they can obtain useful information with relatively few feet of film.

Table 24. Adequacy of Present Film Capacity

Reaction	%
Adequate	78
Inadequate	22

Table 25. Distribution of Increased Film Capacity Requirements

Film capacity, ft	No.	%
200	8	34.8
300	1	4.4
400	4	17.3
500	4	17.3
1,000	3	13.0
2,000	1	4.4
5,000	1	4.4
Over 5,000	1	4.4

Table 26. Interest in Proposed 35-Mm Time-Lapse Camera

Reaction	No.	%
*Interested	*37	*37.5
Not interested	45	45.5
No answer	17	17.0

* Includes 5 (4.9% of the total) who desired a 16-mm single-frame.

Table 27. Interest in 35-Mm Full-Frame, High-Speed Camera

Reaction	No.	%
Interested	30	30
Not interested	56	56
Not at present	6	6
No answer	6	6
Already have	2	2

These users suggested that means be developed for rapid acceleration to operating speed. A number thought that the use of leader attached to a few feet of unexposed film would be a possible solution to this problem. One user reported the installation of a brake on the feed roll of the Fastax camera which permitted him to take four to five runs at low speeds on a single 100-ft roll of film. The acceleration problem remains, however.

Film capacity requirements, of course, depend upon the nature and duration of the phenomenon being studied and the precision of event synchronization. In some cases, the survey brought out that with better event synchronization, present film capacity would prove adequate.

The 22% who reported inadequate film capacity desired the larger capacities shown in Table 25. Transient phenomena of extended duration sometimes require total exposures longer than can be re-

corded with a single Eastman or Fastax Camera. In some cases, the long acceleration period of these cameras has resulted in a requirement of at least 100 ft of film exposed at a given frame frequency.

Some users have employed several cameras operating in closely timed sequence to cover the total period of time desired.

One "unique" suggestion called for the development of a 500- to 10,000-frame/sec camera with a 6-minute capacity at 10,000 frames/-sec! A 235,000-ft roll of 35-mm film would do the trick! Only 44½ miles long!

PROPOSED TIME LAPSE CAMERA

Comments were requested on the proposed development of a 35-mm single-frame, time-lapse camera that could be used for such purposes as recording instrument indications. Although the largest percentage of replies covered in Table 26 were noncommittal, the author feels that a need is definitely indicated because the 37% who expressed interest included the largest users of photographic instrumentation. In general, they are governmental agencies, aircraft companies, research foundations and universities whose work calls for storage and later reading of large quantities of instrument data. To further substantiate these views, it is important to know that 5 replies from interested groups (4.9% of the total) have need for a 16-mm single-frame, time-lapse camera.

One user suggested a time-lapse rate from 1 frame every 5 sec to 16 frames/sec.

PROPOSED 35-MM FULL-FRAME HIGH-SPEED CAMERA

Table 27 shows that 30 users were interested in the future development of a 35-mm full-frame, high-speed motion picture camera. The current 35-mm Fastax camera produces an image one-half standard frame height. Increased vertical acceptance angle and elimination of special projection means are behind this interest in a full-frame high-speed camera.

The two replies indicating that such cameras are already in use refer to the General Radio-Camera used with stroboscopic illumination. There appears to be a definite but small need for the proposed development.

USERS' COMMENTS

The returned questionnaires carried comments on many phases of high-speed photography and other techniques of photographic in-

strumentation. Many, in paraphrased form, have been included in the preceding paragraphs; one most often repeated, and one which appears to be of extreme importance, is the request for more information on all phases of high-speed motion picture photography. Many expressed their willingness to co-operate in interchanging experience.

Camera Development

Frame frequency and film capacity requirements have been discussed previously, while other characteristics suggested for further attention follow.

Many requests called for development of optical systems for high-speed cameras capable of markedly higher resolution than is currently possible with the Eastman and Fastax cameras. This is considered to be the most important camera development problem.

Minimizing the period of acceleration was suggested by many, as were general improvements in resolution, wider assortment of lens focal lengths, faster lenses and better focusing systems.

One laboratory, interested in the study of flame propagation phenomena, requires a camera capable of taking a group of 6 to 10 frames at 10^6 frames/sec, and providing for a minimum light loss in the optical and shutter systems.

Many of the users who reported requirements for increased frame frequencies also were concerned with shorter exposure durations per frame. Interest was expressed in the development of repetitive light sources capable of effective exposure durations per frame of 10^{-6} to 10^{-7} sec, and in the development of Kerr cell and focal plane scanning systems.

A number suggested that current prism-type cameras be modified to permit easy removal of the prism assembly for adaptation to stroboscopic and oscillographic recording. It was further suggested that the manufacturer furnish contactors for synchronization of stroboscopic illumination at various frequencies. Another group requested that a slating device for code marking the beginning and end of each run be built into the camera. A built-in voltmeter to permit check of extension line voltage drop was suggested for low-voltage and low-speed operation.

One user suggested development of a composite intermittent and continuously moving film camera, *i.e.*, removable intermittent, using 70-mm film in short lengths or up to 2,000 ft; but frame frequency range was not mentioned.

Development of a drum-type camera to carry 3 ft to 5 ft of film was also suggested. It would be provided with means for event synchronization and for timing correlation with oscillographic recordings.

Accessory Equipment and Process Development

One research group asked for development of a rigid mount for the Fastax cameras which would permit photography with no image vibration when the object is 8 ft from the camera. It should be equipped with a tilt top and micrometer adjustments. Another group felt that a good, portable tripod for getting into small places was desirable.

One laboratory suggested development of an improved timing device to operate at 1,000 cycles/sec. Better timing indications were thought important by several users. Still another requirement felt to be of particular importance calls for better methods for event synchronization.

An interesting medical study requires high-speed photography of normal human vocal cords in the production of sound, the study of the muscles which influence this action, the recording of endolaryngeal structures before and after vocal cord surgery, particularly those with pathology causing hoarseness, and the photography of the cervical end of the esophagus in laryngectomized patients. Interest was expressed here in the recording of sound synchronized with the high-speed motion picture record.

A step-printer was suggested for development to provide a means for the reduction of data from high-speed photography.

Illumination and Illuminants

A number of comments concerning the development of light sources were received:

(1) One concerned development of a system to permit increase of illumination intensity during the film acceleration.

(2) Development was recommended of stroboscopic sources of 1 microsecond duration or shorter, synchronized with a camera, and capable of illuminating an area of 3 ft $\times$ 4 ft.

(3) A brilliant point source of 10^{-7} second duration was felt necessary on a particular research project.

(4) Development of a concentrated light source for photography through lens extension tubes was suggested.

(5) Another concerned a more intense light source to permit use of smaller apertures with resulting greater depth of field.

(6) Experiments with a 100-w, 6-v light source built into a centrifuge for the study of action in a capillary tube were reported. Results looked hopeful, but this researcher was especially interested in learning about reports of "any work ever done anywhere in a centrifuge."

Need was expressed for a remotely controlled, normal-speed, 16-mm camera operating at frame frequencies up to 200 per sec. Accurate view finder and focusing control together with 400-ft film capacity were also requested.

A number suggested development of still and continuously moving film cameras for cathode-ray tube photography.

Many comments related to the wide utility of high-speed motion picture photography in scientific research and engineering research. It was stated to be the only data-recording method capable of providing information in a large number of investigations. Several emphasized its usefulness in engineering education and in training of nontechnical personnel.

A number thought the Committee was an excellent medium for the interchange of knowledge and affirmed their interest in co-operating in its work.

ANALYSIS AND CONCLUSIONS

Each application of high-speed motion picture photography must be treated as an individual problem. Each requires some element of practice which differs from almost every other use. Thus, any conclusions about what constitutes "standard practice" must be tempered by one's own requirements and practices.

This survey deals essentially with use of the Eastman and Fastax cameras. The manufacturers indicate that those reporting own nearly one-quarter (actually 23.2%) of the cameras extant. Ordinarily, this sampling would be considered adequate. However, 53% of this one-quarter are in the hands of only seven organizations. These are government laboratories which appear to use high-speed photography to a greater extent per camera than do the others. Because there are no frequency of use data currently available, the reader may speculate whether or not this survey reflects accurately the over-all usage picture.

The data in this report are to be evaluated in the light of a partial

picture of the relatively low frame frequency phase of high-speed motion picture photography, that as practiced with the Eastman and Fastax cameras by a small percentage of total users.

The cross-section of the users seems representative and so the author considers that some basic conclusions to be drawn from the data are valid.

Availability of Information

In studying the answers and comments, the author sensed a lack of knowledge about the availability of specialized techniques, cameras and accessory equipment, their characteristics and their limitations. A good portion of equipment suggested for development actually exists in the commercial market. This condition is considered to result, in general, from the relatively undeveloped state of the art, and in particular from the poor exchange of knowledge on all phases of the subject. Many recognized the problem and issued an urgent plea for more information concerning high-speed practices. From his own observations in the very recent past in connection with a Navy-sponsored project, the author cannot over-emphasize this vast and highly important requirement.

Photographic instrumentation is used in virtually all branches of science and engineering. Its practitioners are spread widely and, incidentally, thinly, among the several arts, making difficult the interchange of information. Technical papers delivered before one professional group find slow distribution to other groups in different fields. Finding this information is a most difficult task, for it is spread among an enormous number of technical journals, domestic and foreign. It is difficult to recognize readily articles of interest, for instrumentation itself is only rarely the subject of the article. Publishers have had to limit the length of technical papers, so that much instrumentation data have been presented briefly, if at all.

Many of those reporting requested information about the Society, indicating limited awareness of the Committee and its functions, but indicating also that the Society is being looked to as an important source of technical information on high-speed motion picture photography and related arts. A program sponsored by the Committee is under way for better distribution of information. It should be expanded.

A brief analysis of the survey results follows and is organized by specific subjects.

The survey data on lenses and field sizes seems to present an accurate summation of current practice based upon the characteristics of the lenses now available. Because so many report using their lenses wide open, a lighting problem is shown to exist.

The illumination data reflect practices prior to general availability of the G.E. 750R lamp which is likely to be adapted by those who were accustomed to overvolting reflector spots and floods.

It was somewhat surprising that so relatively few reported the use of professional motion picture incandescent and carbon arc lighting equipment. Once again, the users' comments indicate that some are not aware of the existence of many of the available illuminants which might easily satisfy some of the expressed requirements.

Producing adequate light intensities, however, still poses one of the most serious problems. In some cases, an additional requirement for special spectral distribution exists. While considerable effort is being put into development of light sources not necessarily photographic, much additional work is required.

Film data and comments furnish ground for research leading to improved illumination and resolution characteristics of high-speed cameras.

It is felt that a considerable requirement lies in the rapid negative and reversal processing of high-speed records. Local professional motion picture processing facilities are not generally known to the high-speed photographic practitioner. More extensive use of such facilities may prove of value. Failing such local availability, and this is most often the case, a rapid means for development and also for printing is considered essential. In many investigations, it is vital that the records be studied or measured immediately after exposure. In general, this is not possible. In fact, one of the major deterrents to the use of photographic instrumentation is the time lost between exposure and examination. This problem must be solved before wider utilization of the photographic method is possible or feasible.

The data on frame frequencies used are quite as expected. The frequency range is fixed by the camera design, while the particular frequency used is established by the nature of the phenomenon under investigation.

The requirement expressed for increased frame frequency is considered significant, and while there are a number of domestic and foreign cameras commercially available that can operate in some of the ranges desired, more information concerning frame frequency,

resolution, exposure duration per frame and other characteristics should be published.

The writer is essentially in agreement with the opinion that present film capacity is greater than necessary, especially in quantitative applications. The fundamental problem is one of precise event synchronization. More information on this subject was requested and should be developed.

There are numerous phenomena which can be studied only over a relatively long period of time. In such instances, action may be covered satisfactorily by such expedients as timing several cameras to operate in succession. But there are many special cases where this is not feasible; therefore, a possible requirement for additional film capacity does exist.

Then there is that 44½-mile magazine! There will be a rush for film manufacturing companies' stock when it is developed!

The author expected a greater response than was expressed for the 35-mm single-frame, time-lapse camera. Nonetheless, it is evident that an important requirement exists.

The current 35-mm Fastax produces a frame one-half standard height by standard frame width leading to the suggestion that a full-frame camera, presumably of the same type (*i.e.*, rotating prism, continuously moving film) should be developed. Some expressed the feeling that such a camera must also be capable of higher resolution not necessarily implied by increased frame size.

Those using General Radio cameras (continuously moving film in conjunction with intermittent discharge light sources) felt that they possessed a camera such as proposed. However, frame frequency range is limited to 1,500 per sec for full frame height. Resolution of the resulting film record is high, provided the following ratio is small: Effective exposure duration per frame (t_e) divided by the reciprocal of the frame frequency (t_f).

Development of a full-frame camera with operating characteristics exceeding those of General Radio camera is considered important. Among these characteristics are higher frame frequency, and possibly the ability to photograph subjects in direct illumination (or self-luminous bodies) not possible with stroboscopic illumination systems.

One of the most important requirements, noted briefly by one user, lies in the techniques of data reduction. Rapid and accurate means are becoming increasingly important.

RECOMMENDATIONS

A number of additional recommendations, based primarily upon information brought to light in this survey but corroborated by the Navy study previously referred to,* are respectfully submitted to the Committee and to the membership at large.

Increased Scope of the Committee's Interest

The Society's scope of interest has been said to lie in those fields, the common denominator of which is "film." The Committee, in the same regard, should be concerned with all photographic instrumentation, covering its use in science and engineering for detection, recording, and measurement.† To do so will require active participation of many other professional agencies and societies.

Interchange of Information

A four-point program for the improvement of the interchange of technical information is recommended.

(1) Publicize the Committee and its functions.
(2) Establish effective liaison throughout all science and engineering.
(3) Encourage the greater production of technical papers.
(4) Establish wider presentation and dissemination of technical papers.

In order to implement such a program, the following procedures are suggested.

Effective liaison and active co-operation should be established with technical and professional societies having an interest in photographic instrumentation.‡ A panel might be set up of representatives of societies, such as those suggested in the following list, whose function it would be to keep their own groups fully informed and to inform the Committee of developments in photographic instrumentation of mutual interest.

* At present, this information is classified, but it is hoped that it will be released in the near future. The work was carried out under the auspices of the Office of Naval Research.

† The Committee has increased its scope in accordance with this recommendation and has changed its name to "The High-Speed and Technical Photography Committee"—January, 1950.

‡ The committee has established its "Technical and Scientific Society Liaison Subcommittee" to carry out this recommendation—January, 1950.

Acoustical Soc. of Am.
Am. Chemical Soc.
Am. Inst. of Chemical Engr.
Am. Inst. of Electrical Engr.
Am. Inst. of Physics
Am. Microscopical Soc.
Am. Physical Soc.
Am. Rocket Soc.
Am. Soc. Heating and Ventilating Engr.
Am. Soc. of Mechanical Engr.
Am. Soc. for Metals
Am. Soc. of Photogrammetry
Am. Soc. for Testing Materials
Am. Soc., X-ray and Elec. Diffraction
Am. Welding Soc.
Biological Photographic Assn.
Electron Microscope Soc. of Am.
Illuminating Eng. Soc.
Industrial Management Soc.
Inst. of Aeronautical Sciences
Inst. of Radio Engr.
Instrument Soc. of Am.
Optical Soc. of Am.
Royal Photographic Soc. (Gr. Br.)
Soc. of Automotive Engr.
Soc. for Adv. of Management
Soc. for Applied Spectroscopy
Soc. for Experimental Stress Analysis
Soc. for Non-Destructive Testing
Soc. of Photographic Engr.

In this way, a greater awareness of the Committee's work will be achieved, effective liaison with all branches of science and engineering will be established as suggested and a more effective channel for the presentation and dissemination of information will be achieved.

This liaison should greatly increase technical paper preparation. It will give workers an opportunity to report upon the details and application of photographic instrumentation not currently possible elsewhere.

Manufacturers of equipment should be encouraged to prepare comprehensive papers concerning their products. It is suggested that a standard outline be adopted so that an equipment digest containing all this material may be prepared, with some means established to keep the information current.

Papers should be invited from the leading proponents of photographic instrumentation and users should be encouraged to contribute papers concerning applications. The inter-society co-operation suggested should endeavor to accelerate this technical papers program.

It is suggested that the symposia currently held semi-annually in conjunction with the Society conventions be extended to local meetings more often and in additional localities.

Continuation and expansion of the publication of special supplements to the Society's JOURNAL containing papers on photographic instrumentation are suggested. Perhaps an A and B edition will one day result, comparable to the General and Technical Sections of the *Journal of the Royal Photographic Society*.

It is felt that one of the most important additions to the scientific literature on the subject of photographic instrumentation would be a monthly digest or review (not an abstract) publication patterned

after the admirable French *Science et Industries Photographiques* of M. Louis P. Clerc, containing condensed, concise, illustrated versions of the scientific and engineering literature, both domestic and foreign, of interest to photographic instrumentation. Comprehensive indexing and cross-referencing of this sort of material would aid measurably in determining the prior state of any phase of the art.

Continued Surveys

It is recommended that a program be established to survey comprehensively photographic instrumentation by each of its phases; *e.g.*, illuminants, reduction of data, event synchronization, Schlieren photography, etc.

A Subcommittee on Standards and Definitions

Formation of a subcommittee on Standards and Definitions for Photographic Instrumentation is suggested. In the case of every new scientific field, there has been required a meeting of the minds on definitions and the standards and standard measurement methods necessary for such definitions. It has become increasingly important to define many of these terms on a universally understood basis. Among those terms suggested for definition and for the establishment of standards to support them for high-speed motion picture photography are:

(1) *Effective aperture.*

(2) *Effective exposure duration per frame.*

(3) *Effective flash duration for single- and multiple-flash transient sources,* such as spark gaps, gaseous discharge tubes, and the like.

(4) *Frame frequency categories.* The need for a more concrete basis for the establishment of a frame frequency spectrum to make easier the scientific discussion of high-speed motion picture photography is recommended by the author. He and his colleagues have adopted radio frequency designations and have given definition to "normal speed," "high-speed," "very high-speed" and "ultra-high-speed" photography. Table 23 uses these categories. (See discussion under Frame Frequencies, above.)

ACKNOWLEDGMENTS

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Constitution of the Society of Motion Picture and Television Engineers

ARTICLE I

NAME

The name of this association shall be SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS.

ARTICLE II

OBJECTS

Its objects shall be: Advancement in the theory and practice of engineering in motion pictures, television, and the allied arts and sciences; the standardization of equipment and practices employed therein; the maintenance of a high professional standing among its members; and the dissemination of scientific knowledge by publication.

ARTICLE III

MEETINGS

There shall be an annual meeting and such other regular and special meetings as provided in the Bylaws.

ARTICLE IV

ELIGIBILITY FOR MEMBERSHIP

Any person of good character is eligible to become a member in any grade for which he is qualified in accordance with the Bylaws.

ARTICLE V

OFFICERS

The officers of the Society shall be a President, an Executive Vice-President, a Past-President, an Engineering Vice-President, an Editorial Vice-President, a Financial Vice-President, a Convention Vice-President, a Secretary, and a Treasurer.

The term of office of all elected officers shall be for a period of two years.

The President shall not be eligible to succeed himself in office.

At the conclusion of his term of office the President automatically becomes Past-President.

Under conditions as set forth in the Bylaws, the office of Executive Vice-President may be vacated before the expiration of his term.

A vacancy in any office shall be filled for the unexpired portion of the term in accordance with the Bylaws.

ARTICLE VI

SECTIONS

Sections may be established in accordance with the Bylaws.

ARTICLE VII

BOARD OF GOVERNORS

The Board of Governors shall consist of the President, the Past-President, the five Vice-Presidents, the Secretary, the Treasurer, the Section Chairmen, and twelve elected Governors. An equal number of these elected Governors shall reside within the areas included in the Eastern time zone; the Central time zone; and the Pacific and Mountain time zones. The term of office of all elected Governors shall be for a period of two years.

ARTICLE VIII

AMENDMENTS

This Constitution may be amended as follows: Amendments may originate as recommendations within the Board of Governors, or as a proposal to the Board of Governors, by any ten members of voting grade; when approved by the Board of Governors as set forth in the Bylaws, the proposed amendment shall then be submitted for discussion at the annual meeting or at a regular or special meeting called as provided in the Bylaws. The proposed amendment, together with the discussion thereon, shall then be promptly submitted by mail to all members qualified to vote, as set forth in the Bylaws. Voting shall be by letter ballot mailed with the proposed amendment and discussion to the voting membership. In order to be counted, returned ballots must be received within sixty (60) days of the mailing-out date. An affirmative vote of two thirds of the valid ballots returned, subject to the above time limitations, shall be required to carry the amendment, provided one fifteenth of the duly qualified members shall have voted within the time limit specified herein.

BYLAWS OF THE SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

BYLAW I

MEMBERSHIP

Sec. 1. Membership of the Society shall consist of the following grades: Honorary members, Sustaining members, Fellows, Active members, Associate members and Student members.

An *Honorary member* is one who has performed eminent service in the advancement of engineering in motion pictures, television, or allied arts. An Honorary member shall be entitled to vote and to hold any office in the Society.

A *Sustaining member* is an individual, company, or corporation subscribing substantially to the financial support of the Society.

A *Fellow* is one who shall be not less than thirty years of age and who shall by his proficiency and contributions have attained to an outstanding rank among engineers or executives of the motion picture or television industries. A Fellow shall be entitled to vote and to hold any office in the Society.

An *Active member* is one who shall be not less than twenty-five years of age and shall be or shall have been either one or an equivalent combination of the following:

(a) An engineer or scientist in motion picture, television or allied arts. As such he shall have performed and taken responsibility for important engineering or scientific work in these arts and shall have been in the active practice of his profession for at least three years, or

(b) A teacher of motion picture, television or allied subjects for at least six years in a school of recognized standing in which he shall have been conducting a major course in at least one of such fields, or

(c) A person who by invention or by contribution to the advancement of engineering or science in motion picture, television or allied arts, or to the technical literature thereof, has attained a standing equivalent to that required for Active membership in (a), or

(d) An executive who for at least three years has had under his direction important engineering or responsible work in the motion picture, television or allied industries and who is qualified for direct supervision of the technical or scientific features of such activities. An Active member shall be entitled to vote and to hold any office in the Society.

An *Associate member* is one who shall be not less than eighteen years of age, and shall be a person who is interested in the study of motion picture or television technical problems or connected with the application of them. An Associate member is not privileged to vote, to hold office or to act as chairman of any committee, although he may serve upon any committee to which he may be appointed; and, when so appointed, shall be entitled to the full voting privileges on action taken by the committee.

A *Student member* is any person registered as a student, graduate or undergraduate, in a college, university, or other educational institution of like scholastic standing, who evidences interest in motion picture or television technology. Membership in this grade shall not extend more than one year beyond the termination of the student status described above. A student member shall have the same privileges as an Associate member of the Society.

Sec. 2. All applications for membership or transfer should be made on blank forms provided for the purpose, and shall give a complete record of the applicant's education and experience. Honorary and Fellow grades may not be applied for.

Sec. 3. (a) Honorary membership may be granted upon recommendation of the Honorary Membership Committee when confirmed first by a three-fourths majority vote of those present at a meeting of the Board of Governors, and then by a four-fifths majority vote of all voting members present at any regular meeting or at a special meeting called as stated in the bylaws. An Honorary member shall be exempt from the payment of all dues.

(b) Upon recommendation of the Fellow Award Committee, when confirmed by a three-fourths majority vote by those present at a meeting of the Board of Governors, an Active member may be made a Fellow.

(c) An Applicant for Active membership shall give as references at least two mem-

bers of the grade applied for or of a higher grade. Applicants shall be elected to membership by a three-fourths majority vote of the entire membership of the appropriate Admissions Committee. An applicant may appeal to the Board of Governors if not satisfied with the action of the Admissions Committee, in which case approval of at least three-fourths of those present at a meeting of the Board of Governors shall be required for election to membership or to change the action taken by the Admissions Committee.

(d) An applicant for Associate membership shall give as reference one member of the Society, or two persons not members of the Society who are associated with the motion picture, television, or allied industry. Applicants shall be elected to membership by approval of the Chairman of the appropriate Admissions Committee.

(e) An applicant for Student membership shall be sponsored by a member of the Society, or by a member of the staff of the department of the institution he is attending, this faculty member not necessarily being a member of the Society. Applicants shall be elected to membership by approval of the Chairman of the appropriate admissions committee.

Sec. 4. Any member may be suspended or expelled for cause by a majority vote of the entire Board of Governors, provided he shall be given notice and a copy in writing of the charges preferred against him, and shall be afforded opportunity to be heard ten days prior to such action.

BYLAW II

OFFICERS

Sec. 1. An officer or governor shall be an Honorary member, Fellow, or an Active member.

BYLAW III

BOARD OF GOVERNORS

Sec. 1. The Board of Governors shall transact the business of the Society in accordance with the Constitution and Bylaws.

Sec. 2. The Board of Governors may act on special resolutions between meetings, by letter ballot authorized by the President. An affirmative vote from a majority of the total membership of the Board of Governors shall be required for approval of such resolutions.

Sec. 3. A quorum of ten members of the Board of Governors shall be present to vote on resolutions presented at any meeting. Unless otherwise specified, a majority vote of the Governors present shall constitute approval of a resolution.

Sec. 4. A member of the Board of Governors may not authorize an alternate to act or vote in his stead.

Sec. 5. Vacancies in the offices or on the Board of Governors shall be filled by the Board of Governors until the annual elections of the Society.

Sec. 6. The Board of Governors, when filling vacancies in the offices or on the Board of Governors, shall endeavor to appoint persons who in the aggregate are representative of the various branches or organizations of the industries interested in the activities of the Society to the end that there shall be no substantial predominance upon the Board, as the result of its own action, of representatives of any one or more branches or organizations of such industries.

Sec. 7. The time and place of all except special meetings of the Board of Governors shall be determined by the Board of Governors.

Sec. 8. Special Meetings of the Board of Governors shall be called by the President with the proviso that no meeting shall be called without at least seven days prior notice to all members of the Board by letter or telegram. Such a notice shall state the purpose of the meeting.

BYLAW IV

ADMINISTRATIVE PRACTICES

Sec. 1. Special rules relating to the administration of the Society and known as Administrative Practices shall be established by the Board of Governors and shall be added to or revised as necessary to the efficient pursuit of the Society's objectives.

BYLAW V

COMMITTEES

Sec. 1. All committees, except as otherwise specified, shall be formed and appointed in accordance with the Administrative Practices as determined by the Board of Governors.

Sec. 2. All committees, except as otherwise specified, shall be appointed to act for the term served by the officer charged with appointing the committees or until he terminates the appointment.

Sec. 3. Chairmen of the committees shall not be eligible to serve in such capacity for more than two consecutive terms.

Sec. 4. Standing Committees of the Society to be appointed by the President and confirmed by the Board of Governors are as follows:

Honorary Membership Committee
Journal Award Committee
Nominating Committee
Progress Medal Award Committee
Public Relations Committee
Samuel L. Warner Memorial Award Committee

Sec. 5. There shall be an Admissions Committee for each Section of the Society composed of a chairman and three members of which at least two shall be members of the Board of Governors.

Sec. 6. There shall be a Fellow Award Committee composed of all the officers and section chairmen of the Society under the chairmanship of the Past-President. In case the chairmanship is vacated it shall be temporarily filled by appointment by the President.

BYLAW VI

MEETINGS OF THE SOCIETY

Sec. 1. The location and time of each meeting or convention of the Society shall be determined by the Board of Governors.

Sec. 2. The grades of membership entitled to vote are defined in Bylaw I.

Sec. 3. A quorum of the Society shall consist in number of $\frac{1}{15}$ of the total of those qualified to vote as listed in the Society's records at the close of the last fiscal year before the meeting.

Sec. 4. The annual meeting shall be held during the fall convention.

Sec. 5. Special meetings may be called by the President and upon the request of any three members of the Board of Governors not including the President.

Sec. 6. All members of the Society in any grade shall have the privilege of discussing technical material presented before the Society or its Sections.

BYLAW VII

DUTIES OF OFFICERS

Sec. 1. The President shall preside at all business meetings of the Society and shall perform the duties pertaining to that office. As such he shall be the chief executive of the Society, to whom all other officers shall report.

Sec. 2. In the absence of the President, the officer next in order as listed in Article V of the Constitution shall preside at meetings and perform the duties of the President.

Sec. 3. The seven officers shall perform the duties separately enumerated below and those defined by the President:

(a) The Executive Vice-President shall represent the President, and shall be responsible for the supervision of the general affairs of the Society as directed by the President.

The President and the Executive Vice-President shall not both reside in the geographical area of the same Society Section, but one of these officers shall reside in the vicinity of the executive offices. Should the President or Executive Vice-President remove his residence to the same geographical area of the United States as the other, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President shall be elected by the Board of Governors for the unexpired portion of the term.

(b) The Engineering Vice-President shall appoint all technical committees. He shall be responsible for the general initiation, supervision, and co-ordination of the work of these committees.

(c) The Editorial Vice-President shall be responsible for the publication of the Society's *Journal* and all other Society publications.

(d) The Financial Vice-President shall be responsible for the financial operations of the Society, and shall conduct them in accordance with budgets prepared by him and approved by the Board of Governors.

(e) The Convention Vice-President shall be responsible for the national conventions of the Society. He shall arrange for at least one annual convention to be held in the fall of the year.

Sec. 4. The Secretary shall keep a record of all meetings; and shall have the responsibility for the care and custody of records, and the seal of the Society.

Sec. 5. The Treasurer shall have charge of the funds of the Society and disburse them as and when authorized by the Financial Vice-President. He shall be bonded in an amount to be determined by the Board of Governors, and his bond shall be filed with the Secretary.

Sec. 6. Each officer of the Society, upon the expiration of his term of office, shall

transmit to his successor a memorandum outlining the duties and policies of his office.

BYLAW VIII
SOCIETY ELECTIONS

Sec. 1. All officers and governors shall be elected to their respective offices by a majority of ballots cast by voting members in the following manner:

Nominations shall first be presented by a Nominating Committee appointed by the President, consisting of nine members, including a Chairman. The committee shall be made up of two Past-Presidents, three members of the Board of Governors not up for election, and four other voting members, not currently officers or governors of the Society. Nominations shall be made by three-quarters affirmative vote of the total Nominating Committee.

Not less than three months prior to the Annual Fall Meeting, the Board of Governors shall review the recommendations of the Nominating Committee, which shall have nominated suitable candidates for each vacancy.

Such nominations shall be final unless any nominee is rejected by a three-quarters vote of the Board of Governors present and voting. The Secretary shall then notify these candidates of their nomination. From the list of acceptances, not more than three names for each vacancy shall be selected by the Board of Governors and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the name of any voting member other than those suggested by the Board of Governors may be voted for. The balloting shall then take place. The ballot shall be enclosed with a blank envelope and a business reply envelope bearing the Secretary's address and a space for the member's name and address. One set of these shall be mailed to each voting member of the Society, not less than forty days in advance of the annual fall meeting.

The voter shall then indicate on the ballot one choice for each vacancy, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention.

The sealed envelope shall be delivered by the Secretary to a Committee of Tellers appointed by the President at the annual fall convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly-elected officers and governors of the Society shall take office on January 1, following their election.

BYLAW IX
DUES AND INDEBTEDNESS

Sec. 1. The annual dues shall be fifteen dollars ($15) for Fellows and Active members, ten dollars ($10) for Associate members, and five dollars ($5) for Student members, payable on or before January 1, of each year. Current or first year's dues for new members in any calendar year shall be at the full annual rate for those notified of election to membership on or before June 30; one half the annual rate for those notified of election to membership in the Society on or after July 1.

Sec. 2. (a) Transfer of membership to a higher grade may be made at any time subject to the requirements for initial membership in the higher grade. If the transfer is made on or before June 30, the annual dues of the higher grade are required. If the transfer is made on or after July 1, and the member's dues for the full year have been paid, one half of the annual dues of the higher grade is payable less one half the annual dues of the lower grade.

(b) No credit shall be given for annual dues in a membership transfer from a higher to a lower grade, and such transfers shall take place on January 1, of each year.

Sec. 3. Annual dues shall be paid in advance.

Sec. 4. Failure to pay dues may be considered just cause for suspension.

BYLAW X
PUBLICATIONS

Sec. 1. The Society shall publish a technical magazine to consist of twelve monthly issues, in two volumes per year. The editorial policy of the *Journal* shall be based upon the provisions of the Constitution and a copy of each issue shall be supplied to each member in good standing mailed to his last address of record.

Copies may be made available for sale at a price approved by the Board of Governors.

BYLAW XI

LOCAL SECTIONS

Sec. 1. Sections of the Society may be authorized in any locality where the voting membership exceeds twenty. The geographic boundaries of each Section shall be determined by the Board of Governors. Upon written petition for the authorization of a Section of the Society, signed by twenty or more voting members, the Board of Governors may grant such authorization.

SECTION MEMBERSHIP

Sec. 2. All members of the Society of the Motion Picture and Television Engineers in good standing residing within the geographic boundaries of any local Section shall be considered members of that Section.

Sec. 3. Should the enrolled voting membership of a Section fall below twenty, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining that Section, the Board of Governors may cancel its authorization.

SECTION OFFICERS

Sec. 4. The officers of each Section shall be a Chairman and a Secretary-Treasurer. The Section chairmen shall be ex-officio members of the Board of Governors and shall continue in such positions for the duration of their terms as chairmen of the local Sections. Each Section officer shall hold office for one year, or until his successor is chosen.

SECTION BOARD OF MANAGERS

Sec. 5. The Board of Managers shall consist of the Section Chairman, the Section Past-Chairman, the Section Secretary-Treasurer, and six voting members. Each manager of a Section shall hold office for two years. Vacancies shall be filled by appointment by the Board of Managers until the annual election of the Section.

SECTION ELECTIONS

Sec. 6. The officers and managers of a Section shall be voting members of the Society. All officers and managers shall be elected to their respective offices by a majority of ballots cast by the voting members residing in the geographical area of the Section. Not less than three months prior to the annual fall convention of the Society, nominations shall be presented to the Board of Managers of the Section by a Nominating Committee appointed by the Chairman of the Section, consisting of seven members, including a chairman. The committee shall be composed of the present Chairman, the Past-Chairman, two other members of the Board of Managers not up for election, and three other voting members of the Section not currently officers or managers of the Section. Nominations shall be made by a three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final, unless any nominee is rejected by a three-quarters vote of the Board of Managers, and in the event of such rejection the Board of Managers will make its own nomination.

The Chairman of the Section shall then notify the candidates of their nomination. From the list of acceptances, not more than three names for each vacancy shall be selected by the Board of Managers and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the name of any voting member other than those suggested by the Board of Managers may be voted for. The balloting shall then take place. The ballot shall be enclosed with a blank envelope and a business reply envelope bearing the local Secretary-Treasurer's address and a space for the member's name and address. One of these shall be mailed to each voting member of the Society residing in the geographical area covered by the Section, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary-Treasurer, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention. The sealed envelopes shall be delivered by the Secretary-Treasurer to his Board of Managers at a

duly called meeting. The Board of Managers shall then examine the returned envelopes, open and count the ballots, and announce the results of the election.

The newly-elected officers and managers shall take office on January 1, following their election.

SECTION BUSINESS

Sec. 7. The business of a Section shall be conducted by the Board of Managers.

SECTION EXPENSES

Sec. 8. (a) At the beginning of each fiscal year, the Secretary-Treasurer of each section shall submit to the Board of Governors of the Society a budget of expenses for the year.

(b) The Treasurer of the Society shall deposit with each Section Secretary-Treasurer a sum of money for current expenses, the amount to be fixed by the Board of Governors.

(c) The Secretary-Treasurer of each Section shall send to the Treasurer of the Society, quarterly or on demand, an itemized account of all expenditures incurred during the preceding period.

(d) Expenses other than those enumerated in the budget, as approved by the Board of Governors of the Society, shall not be payable from the general funds of the Society without express permission from the Board of Governors.

(e) The Section Board of Managers shall defray all expenses of the Section not provided for by the Board of Governors, from funds raised locally.

(f) The Secretary of the Society shall, unless otherwise arranged, supply to each Section all stationery and printing necessary for the conduct of its business.

SECTION MEETINGS

Sec. 9. The regular meetings of a Section shall be held in such places and at such hours as the Board of Managers may designate. The Secretary-Treasurer of each Section shall forward to the Secretary of the Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

CONSTITUTION AND BYLAWS

Sec. 10. Sections shall abide by the Constitution and Bylaws of the Society and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

BYLAW XII

STUDENT CHAPTERS

Sec. 1. Student Chapters of the Society may be authorized in any college, university, or technical institute of collegiate standing. Upon written petition for the authorization of a Student Chapter, signed by twelve or more Society members, or applicants for Society membership, and the Faculty Adviser, the Board of Governors may grant such authorization.

CHAPTER MEMBERSHIP

Sec. 2. All members of the Society in good standing who are attending the designated educational institution shall be eligible for membership in the Student Chapter, and when so enrolled they shall be entitled to all privileges that such Student Chapter may, under the Constitution and Bylaws, provide.

Sec. 3. Should the membership of the Student Chapter fall below ten, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

CHAPTER OFFICERS

Sec. 4. The officers of each Student Chapter shall be a Chairman and a Secretary-Treasurer. Each Chapter officer shall hold office for one year, or until his successor is chosen. Where possible, officers shall be chosen in May to take office at the beginning of the following school year. The procedure for holding elections shall be prescribed in Administrative Practices.

FACULTY ADVISER

Sec. 5. A member of the faculty of the same educational institution shall be designated by the Board of Governors as Faculty Adviser. It shall be his duty to advise the officers on the conduct of the Chapter and to approve all reports to the Secretary and the Treasurer of the Society.

CHAPTER EXPENSES

Sec. 6. The Treasurer of the Society shall deposit with each Chapter Secretary-Treasurer a sum of money, the amount to be fixed by the Board of Governors. The Secretary-Treasurer of the Chapter shall send to the Treasurer of the Society at the

end of each school year or on demand an itemized account of all expenditures incurred.

CHAPTER MEETINGS

Sec. 7. The Chapter shall hold at least four meetings per year. The Secretary-Treasurer shall forward to the Secretary of the Society at the end of each school year a report of the meetings for that year, giving the subject, speaker, and approximate attendance for each meeting.

BYLAW XIII

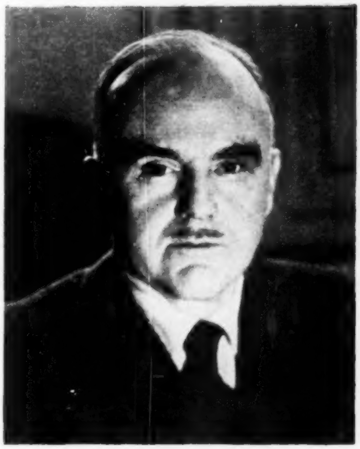
AMENDMENTS

Sec. 1. Proposed amendments to these Bylaws may be initiated by the Board of Governors or by a recommendation to the Board of Governors signed by ten voting members. Proposed amendments may be approved at any regular meeting of the Society at which a quorum is present, by the affirmative vote of two-thirds of the members present and eligible to vote thereon. Such proposed amendments shall have been published in the *Journal* of the Society, in the issue next preceding the date of the stated business meeting of the Society at which the amendment or amendments are to be acted upon.

Sec. 2. In the event that no quorum of the voting members is present at the time of the meeting referred to in Sec. 1, the amendment or amendments shall be referred for action to the Board of Governors. The proposed amendment or amendments then become a part of the Bylaws upon receiving the affirmative vote of three-quarters of the entire membership of the Board of Governors.

OFFICERS OF THE SOCIETY April, 24, 1950

Peter Mole
Executive Vice-President
1949–50

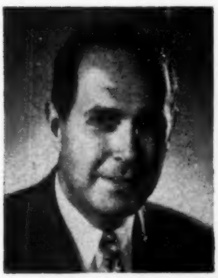


Earl I. Sponable
President
1949–50

Loren L. Ryder
Past-President
1949–50

Fred T. Bowditch
Engineering Vice-President
1950–51

Clyde R. Keith
Editorial Vice-President
1949–50



Ralph B. Austrian
Financial Vice-President
1950–51

William C. Kunzmann
Convention Vice-President
1949–50

Robert M. Corbin
Secretary
1949–50

Frank E. Cahill, Jr.
Treasurer, 1950–51

Herbert Barnett
Governor, 1949–50

Kenneth F. Morgan
Governor, 1949–50

Norwood L. Simmons
Governor, 1949–50

J. P. Livadary
Governor, 1950

William B. Lodge
Governor, 1950

Lorin D. Grignon
Governor, 1950–51

Paul J. Larsen
Governor, 1950–51

William H. Rivers
Governor, 1950–51

R. T. Van Niman
Governor, 1950–51

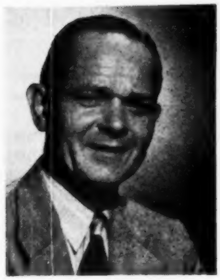
Edward S. Seeley
Governor, 1950–51

Malcolm G. Townsley
Governor, 1950

Frank E. Carlson
Governor, 1950

Edward Schmidt
Governor, 1950

George W. Colburn
Governor, 1950



Charles R. Daily
Governor, 1950

OFFICERS AND MANAGERS OF SECTIONS

ATLANTIC COAST: *Chairman,* Edward Schmidt; *Secretary-Treasurer,* H. C. Milholland; *Managers,* E. A. Bertram, E. Dudley Goodale, R. G. Mann, Pierre Mertz, R. E. Shelby, E. M. Stifle

CENTRAL: *Chairman,* G. W. Colburn; *Secretary-Treasurer,* C. E. Heppberger; *Managers,* F. E. Carlson, E. W. D'Arcy, R. E. Lewis, A. Shapiro, Lloyd Thompson, M. G. Townsley

PACIFIC COAST: *Chairman,* C. R. Daily; *Secretary-Treasurer,* Vaughn Shaner; *Managers,* Larry Aicholtz, G. M. Best, L. D. Grignon, J. P. Livadary, Roy Monfort, E. H. Reichard

STUDENT CHAPTER OFFICERS

NEW YORK UNIVERSITY: *Chairman,* William F. Boden; *Secretary-Treasurer,* Gerald I. Rosenfeld

UNIVERSITY OF SOUTHERN CALIFORNIA: *Chairman,* Melvin R. Kells; *Secretary-Treasurer,* Eric T. Sjolander

William F. Boden
Chairman,
New York University

Melvin R. Kells
Chairman, University of Southern California

TREASURER'S REPORT

January 1—December 31, 1949

Cash		
Cash on Deposit, Chase National Bank, January 1, 1949	$6,483.68	
Net Receipts	(352.24)	
Cash on Deposit, Chase National Bank, December 31, 1949		$6,131.44
Petty Cash Fund		200.00
Total Cash on Hand and in Bank		6,331.44
Investments		
Savings Accounts, January 1, 1949	$15,193.75	
Add: Interest Credited	510.61	
Savings Accounts, December 31, 1949	$15,704.36	
U. S. Government Bonds (at cost)	60,000.00	
Total Investments		75,704.36
Total Cash and Investments, December 31, 1949		$82,035.80

Respectfully submitted,
RALPH B. AUSTRIAN, Treasurer

SUMMARY OF FINANCIAL CONDITION

December 31, 1949

Assets (What Your Society Owns)	
Cash on Hand and in Bank	$ 6,331.44
Savings Accounts	15,704.36
U. S. Government Bonds (at cost)	60,000.00
Accounts Receivable	9,717.29
Book Inventory	1,000.00
Test Film Inventory	3,304.41
Test Film Equipment (depreciated value)	7,461.71
Office Furniture and Equipment (memo value)	1.00
Total Assets	$103,520.21
Liabilities (What Your Society Owes)	
Accounts Payable	$ 1,399.97
Customers Payments Received in Advance	984.93
Membership Dues Received in Advance	8,810.03
New York City Sales Tax Payable	13.27
Reserve for 1950 Five Year Index	2,000.00
Total Liabilities	$ 13,208.20
Members' Equity (What Your Society Is Worth)	$ 90,312.01
Total Liabilities and Members' Equity	$103,520.21

STATEMENT OF INCOME AND EXPENSES

January 1—December 31, 1949

Test Film Operations		
Total Test Film Sales	$37,166.64	
Cost of Test Films Sold	23,384.25	
Net Income from Test Film Operations		$13,782.39
Publications Operations		
Total Publications Income	$21,222.97	
Net Cost of Publications	41,668.27	
Net Loss from Publications Operations		(20,445.30)
Other Operations		
Total Income from Other Operations	$ 571.20	
Cost of Other Operations	344.60	
Net Income from Other Operations		226.60
Other Income		
Membership Dues	$57,046.45	
Interest Earned	1,961.86	
Total Other Income		59,008.31
Total Operating Income		$52,572.00
Operating Expenses		
Engineering	$10,249.52	
Non-Engineering	2,029.82	
General Office and Administrative	38,752.50	
Officers	171.65	
Sections	2,275.00	
SMPE Affiliations	1,100.00	
Conventions (Net)	299.46	
Total Operating Expenses		54,877.95
Net Operating Loss		$(2,305.95)
Other Deductions		
Depreciation of Test Film Equipment	$ 3,730.86	
Provision for 1950 Five Year Index	500.00	
Total Other Deductions		4,230.85
Excess of Expenses Over Income		$(6,536.81)

THE FOREGOING financial statements were prepared from the records of the Society for the year 1949 and reflect the results of operations for that year. The records and financial statements were audited for the year ended December 31, 1949, by Sparrow, Waymouth and Company, Certified Public Accountants, New York City, and are in conformity with that audit.

D. B. JOY, Financial Vice-President

MEMBERSHIP REPORT

For Year Ended December 31, 1949

	Hon.	Sust.	Fel.	Act.	Assoc.	Stud.	Total
Membership, January 1, 1949	4	70	178	734	1760	154	2900
New Members		4		185	283	108	580
Reinstatements				10	12	2	24
	4	74	178	929	2055	264	3504
Resignations	−2	−7		−8	−38	−3	−58
Deceased			−2	−5	−8		−15
Delinquents			−3	−56	−193	−32	−284
	2	67	173	860	1816	229	3147
Changes in Grade:							
Active to Fellow			14	−14			
Associate to Active				24	−24		
Student to Active				2		−2	
Active to Associate				−1	1		
Student to Associate					7	−7	
Membership, December 31, 1949	2	67	187	871	1800	220	3147

NONMEMBER SUBSCRIPTION REPORT

For Year Ended December 31, 1949

Subscriptions, January 1, 1949	767
New Subscriptions	376
	1143
Cutoffs and Expirations	645
Subscriptions, December 31, 1949	488

Meetings of Other Societies

Acoustical Society of America, Spring Meeting, June 22–24, State College, Pa.

Illuminating Engineering Society, National Technical Conference, Aug. 21–25, Pasadena, Calif.

Biological Photographic Assn., Annual Meeting, Sept. 6–8, Hotel Sheraton, Chicago

Institute of Radio Engineers, West Coast Convention, Sept. 13–15, Long Beach, Calif.

Audio Engineering Society, National Convention, Oct. 26–28, Hotel New Yorker, New York

Optical Society of America, Oct. 26–28, New York, N.Y.

Acoustical Society of America, Fall Meeting, Nov. 9–11, Boston, Mass.

Awards

In accordance with the provisions of the Administrative Practices of the Society and the regulations for granting the Journal Award, the Progress Medal Award and the Samuel L. Warner Memorial Award, a list of names of previous recipients, and the reasons therefor are published annually in the Journal as follows:

JOURNAL AWARD

The Journal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

At the fall convention of the Society a Journal Award Certificate shall be presented to the author or to each of the authors of the most outstanding paper originally published in the Journal of the Society during the preceding calendar year.

Other papers published in the Journal of the Society may be cited for Honorable Mention at the option of the Committee, but in any case should not exceed five in number.

The Journal Award shall be made on the basis of the following qualifications:

(1) The paper must deal with some technical phase of motion picture engineering.

(2) No paper given in connection with the receipt of any other Award of the Society shall be eligible.

(3) In judging of the merits of the paper, three qualities shall be considered, with the weights here indicated: (a) technical merit and importance of material, 45%; (b) originality and breadth of interest, 35%; and (c) excellence of presentation of the material, 20%.

A majority vote of the entire Committee shall be required for the election to the Award. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

These regulations, a list of the names of those who have previously received the Journal Award, the year of each Award, and the titles of the papers shall be published annually in the Journal of the Society. In addition, the list of papers selected for Honorable Mention shall be published in the Journal of the Society during the year current with the Award.

The recipients are listed below by year, with the date of Journal publication given after the title.

1934, P. A. Snell, "An introduction to the experimental study of visual fatigue," May 1933.

1935, L. A. Jones and J. H. Webb, "Reciprocity law failure in photographic exposure," Sept. 1934.

1936, E. W. Kellogg, "A comparison of variable-density and variable-width systems," Sept. 1935.

1937, D. B. Judd, "Color blindness and anomalies of vision," June 1936.

1938, K. S. Gibson, "The analysis and specification of color," Apr. 1937.

1939, H. T. Kalmus, "Technicolor adventures in cinemaland," Dec. 1938.

1940, R. R. McNath, "The surface of the nearest star," Mar. 1939.

1941, J. G. Frayne and Vincent Pagliarulo, "The effects of ultraviolet light on variable-density recording and printing," June 1940.

1942, W. J. Albersheim and Donald MacKenzie, "Analysis of soundfilm drives," July 1941.

1943, R. R. Scoville and W. L. Bell, "Design and use of noise-reduction bias systems," Feb. 1942 (Award made Apr. 1944).

1944, J. I. Crabtree, G. T. Eaton and M. E. Muehler, "Removal of hypo and silver salts from photographic materials as affected by the composition of the processing solutions," July 1943.

1945, C. J. Kunz, H. E. Goldberg and C. E. Ives, "Improvement in illumination efficiency of motion picture printers," May 1944.

1946, R. H. Talbot, "The projection life of film," Aug. 1945.

1947, Albert Rose, "A unified approach to the performance of photographic film, television pickup tubes, and the human eye," Oct. 1946.

1948, J. S. Chandler, D. F. Lyman and L. R. Martin, "Proposals for 16-mm and 8-mm sprocket standards," June 1947.

1949, F. G. Albin, "Sensitometric aspect of television monitor-tube photography," Dec. 1948.

The present Chairman of the Journal Award Committee is C. R. Daily.

PROGRESS MEDAL AWARD

The Progress Medal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

The Progress Medal may be awarded each year to an individual in recognition of any invention, research or development which, in the opinion of the Committee, shall have resulted in a significant advance in the development of motion picture technology.

Any member of the Society may recommend persons deemed worthy of the Award. The recommendation in each case shall be in writing and in detail as to the accomplishments which are thought to justify consideration. The recommendation shall be seconded in writing by any two Fellows or Active members of the Society, who shall set forth their knowledge of the accomplishments of the candidate which, in their opinion, justify consideration.

A majority vote of the entire Committee shall be required to constitute an Award of the Progress Medal. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

The recipient of the Progress Medal shall be asked to present a photograph of himself to the Society and, at the discretion of the Committee, may be asked to prepare a paper for publication in the Journal of the Society.

These regulations, a list of the names of those who have previously received the Medal, the year of each Award and a statement of the reason for the Award shall be published annually in the Journal of the Society.

Awards have been made as follows:

1935, E. C. Wente, for his work in sound recording and reproduction, Dec. 1935.

1936, C. E. K. Mees, for his work in photography, Dec. 1936.

1937, E. W. Kellogg, for his work in sound reproduction, Dec. 1937.

1938, H. T. Kalmus, for his work in developing color motion pictures, Dec. 1938.

1939, L. A. Jones, for his scientific researches in photography, Dec. 1939.

1940, Walt Disney, for his contributions to motion picture photography and sound recording of feature and short cartoon films, Dec. 1940.

1941, G. L. Dimmick, for his development activities in motion picture sound recording, Dec. 1941.

No Awards were made in 1942 and 1943.

1944, J. G. Capstaff, for his research and development of films and apparatus used in amateur cinematography, Jan. 1945.

No Awards were made in 1945 and 1946.

1947, J. G. Frayne, for his technical achievements and the documenting of his work in addition to his contributions to the field of education and his inspiration to his fellow engineers, Jan. 1948.

1948, Peter Mole for his outstanding achievements in motion picture studio lighting which set a pattern for lighting techniques and equipment for the American motion picture industry, Jan. 1949.

1949, Harvey Fletcher for his outstanding contributions to the art of recording and reproducing of sound for motion pictures, Oct. 1949.

The present Chairman of the Progress Medal Award Committee is J. G. Frayne.

SAMUEL L. WARNER MEMORIAL AWARD

Each year the President shall appoint a Samuel L. Warner Memorial Award Committee consisting of a chairman and four members. The chairman and committee members must be Active Members or Fellows of the Society. In considering candidates for the Award, the committee shall give preference to inventions or developments occurring in the last five years. Preference should also be given to the invention or development likely to have the widest and most beneficial effect on the quality of the reproduced sound and picture. A description of the method or apparatus must be available for publication in sufficient detail so that it may be followed by anyone skilled in the art. Since the Award is made to an individual, a development in which a group participates should be considered only if one person has contributed the basic idea and also has contributed substantially to the practical working out of the idea. If, in any year, the committee does not consider any recent development to be more than the logical working out of details along well-known lines, no recommendation for the Award shall be made. The recommendation of the committee shall be presented to the Board of Governors at the July meeting.

The purpose of this Award is to encourage the development of new and improved methods or apparatus designed for sound-on-film motion pictures, including any step in the process.

Any person, whether or not a member of the Society of Motion Picture and Television Engineers, is eligible to receive the Award.

The Award shall consist of a gold medal suitably engraved for each recipient. It shall be presented at the Fall Convention of the Society, together with a bronze replica.

These regulations, a list of those who previously have received the Award, and a statement of the reason for the Award shall be published annually in the JOURNAL of the Society. The recipients have been:

1947, J. A. Maurer, for his outstanding contributions to the field of high-quality 16-mm sound recording and reproduction, film processing, development of 16-mm sound test films, and for his inspired leadership in industry standardization (citation published, Jan. 1948).

1948, Nathan Levinson, for his outstanding work in the field of motion picture sound recording, the intercutting of variable-area and variable-density sound tracks, the commercial use of control track for extending volume range, and the use of the first soundproof camera blimps (citation published, Jan. 1949).

1949, R. M. Evans, for his outstanding work in the field of color motion picture films, including research on visual effects in photography and development work on commercial color processes (citation published, Oct. 1949).

The present Chairman of the Samuel L. Warner Memorial Award Committee is W. V. Wolfe.

Board of Governors

The second meeting of the Board of Governors for 1950 was held on Sunday, April 23, in The Drake hotel, Chicago, preceding by one day the opening of the Society's 67th Semiannual Convention. The Board members reviewed the Society's accomplishments and financial picture for the three months just completed. Plans for future committee activities that are supervised by the Officers and Headquarters Staff were also considered at length.

President Sponable introduced F. E. Carlson and M. G. Townsley, recently appointed Governors from the Central Zone, who had been chosen to fill two recently created Governorships that otherwise would have remained vacant until 1951.

Current activities, reported on by Boyce Nemec, Executive Secretary, included the Society's programs for test films, memberships and the JOURNAL.

Sales of 16- and 35-mm test films have remained at a high level, continuing to exceed production so that a number of back orders are still on the books. Production forecasts for the immediate future indicate that deliveries will catch up with orders by the third week in July, and after that it should be possible to begin building an inventory of all films. Twenty-four hour service on all orders for reasonable quantities of any of the films is the prime objective.

The engineering committees have had an abiding interest in generally improving technical performance in the 16-mm field. Recently, steps have been taken in this direction to interest service shops, dealers, and distributors of 16-mm projectors in the test films now available from both the Society and the Research Council. Increased distribution and use of all test films is expected and this program deserves the support of all members.

Users of high-speed photography have recently taken great interest in the work of the Society's High-Speed Photography Committee and in the articles on the subject that appeared in the JOURNAL within the past year. Those who contributed to the Committee's 1949 Survey and their associates, who are not now members of the Society, have been invited to join. A considerable increase in membership from this field, which includes all phases of scientific photography, should result. The Board of Governors endorsed this program enthusiastically, and urged that service engineers whose field is the maintenance of theater and television equipment should also be invited to apply for membership. This is being done and there will no doubt be a further increase of membership in all grades from this quarter.

Now that many of the engineering committees are becoming increasingly active, the amount of correspondence, duplicating, mailing and other overhead required to maintain this level of activity is also increasing. A further increase of administrative expenses is attributed to recent improvements in the JOURNAL, stemming from the gradual revision of typography, together with results from current membership promotion, which necessitates a larger print order each month. Fortunately, however, there are compensating factors here, such as reduced unit cost of the JOURNAL brought about by the increased print order, which takes advantage of quantity production economies. The fiscal picture at the end of the first quarter is an encouraging one but actually is only a beginning, compared with what the Society can do if its members will get squarely behind the present membership and test film programs.

Engineering Vice-President Bowditch reviewed briefly the work of the eighteen different engineering committees that are now active, including the reorganization of television work, reported on page 509 of the April JOURNAL. The outcome of this program, which stresses co-operation with the Institute of Radio Engineers and the Radio Manufacturers Association, should be in the direction of more effective committee work in all three organizations with a minimum of effort. Continuing JOURNAL reports on the Society's work in theater television were requested, at least until conclusive action is taken by the FCC.

Editorial Vice-President Keith reported the receipt of two replies to the article on Research Fellowships that had appeared in the February JOURNAL. The Illuminating Engineering Society currently has a committee considering the granting of such Fellowships, and it was suggested that Mr. Keith look into the matter with representatives from the IES.

The recently proposed Amendments to the Constitution and Bylaws have received official endorsement, and now the committee, under the Society's Secretary, Robert M. Corbin, responsible for that work, has accepted the job of revising the Administrative Practices. These are a set of Board-approved rules governing in a practical way the operations of Society Headquarters and the Society's many committees. Changes will be recommended in order to bring the Administrative Practices into line with the present Constitution and Bylaws.

The next meeting of the Board of Governors, scheduled for July 26, will be held in New York City. In the meantime, the Sustaining Membership Committee, the Membership and Subscription Committee and Society Headquarters will bend every effort toward increasing support which the Society receives.

67th Convention

The Society's 67th Convention opened officially on April 24 with a luncheon at The Drake hotel in Chicago. Members who attended the luncheon were treated to a very enthusiastic statement of intentions in theater television presented by Spyros P. Skouras, President of the Twentieth Century-Fox Film Corp. Mr. Skouras indicated with some emphasis that his company intended to proceed with plans to establish a theater television network in a West Coast area without waiting for formal action by the Federal Communications Commission. Arrangements would be made with the local telephone companies for cable service between theaters and the originating point. Action, he stated, would be taken by early 1951.

Attendance at the Convention was more than satisfactory, with over 200 registrants for the week and an additional 100 daily registrants for each of the five days of the week-long meeting.

Outstanding among those attending were four members of the University of Southern California Student Chapter: Algernon Walker, James L. Wilkinson, William R. Kells and Eric T. Sjolander; and Wilbur T. Blume, a member of the USC Faculty. These five members drove from California to Chicago, stopping at universities along the way to inspect motion picture production and visual education facilities.

There was a total of eleven committee meetings held during the week, running from Sunday, April 23 through Saturday, April 29. Future issues of the JOURNAL will carry progress reports on the work of the majority of these committees.

On Tuesday evening those who attended the convention were guests of WGN-TV Television Station and were escorted through the Tribune Tower Studios at 435 N. Michigan Ave. The studios have been under construction for some time and members who are familiar with studio design and the solution of architectural and acoustics problems were tremendously interested in the choice of materials and their application to this impressive arrangement of combined television and radio facilities. The Society extends its enthusiastic gratitude to Carl Meyers, Director of Engineering, and F. R. McNichol, Engineering Department, WGN TV.

On Wednesday evening, the semiannual Cocktail Hour, Banquet and Dance were held in the Gold Coast Room of The Drake hotel. Bill Kunzmann was as always the Society's genial host and provided a most entertaining evening for all.

On Thursday evening, Wilding Picture Productions was host to Society members who visited the studio at 1345 Argyle St.

The Convention closed late Friday afternoon, April 28, with a few encouraging words from Mr. Kunzmann, who reports that in all respects the Convention was more than a modest success. Papers presented will begin to appear in the JOURNAL beginning in the late summer and will probably continue until about the first of 1951.

Theater Carpeting Manuals Available

The Theater Engineering Committee has for some time contemplated publishing a report on theater carpeting that would be a generally useful guide to theater owners and operators who purchase fairly large quantities of carpeting. It would necessarily have to be quite comprehensive in presenting recommended practices for the selection, maintenance and care of theater carpet based upon actual theater experience. After considerable work in this direction had been undertaken, in the form of a survey, it was decided that certain publications already available adequately covered the major questions on theater and hotel carpeting. The SMPTE has, therefore, made arrangements to secure for interested persons a package of the following two publications:

Handbook for Carpet Layers, The Carpet Institute, Inc.

Carpets and Their Maintenance, prepared for The American Hotel Association by The York Research Corp., in co-operation with The Carpet Institute, Inc., and The National Institute of Rug Cleaners, Inc.

The Committee feels that with this information at hand, and with his personal experience, the average theater man will have available *nearly* all that he needs to know about the subject.

In reviewing these documents, however, various members of the Committee agreed that there are a few additional points unique to theater work that should be added. Pattern selection, for instance, should depend not only on the theater motif, but on the size of the floor areas involved. Large areas usually demand a larger pattern, and the trend has been toward larger patterns with repeats as great as 60 in. Matching background designs are also available without the large pattern, so that the over-all pattern can be used in a foyer and standee area, and the stairways can carry the matched background only. In this way, the large

pattern cannot camouflage or confuse the outlines of the stair treads and risers, and so a higher safety factor can be maintained.

Many theater operators create a much more favorable maintenance schedule by using 54-in. widths rather than 27-in. widths in aisles and standee areas, on stairways and in other heavily traveled areas. This eliminates extra seams which are always a problem as the carpet wears.

Color selection should be studied in every installation. Bright colors that soil "gracefully" and still retain a live look are desirable. Reds and golds especially fall into this class. The manufacturer can give valuable guidance in this instance. Consideration must also be given to color mixing. The problem here is like mixing oil colors in a pot. Green lighting on red carpeting will result in a dead, black effect. Rose or flame-tint lighting, on the other hand, will enhance and soften the effect of red carpeting. A definite trend, however, has been the utilization of low wattage concealed down lighting that *suffuses* the carpeted areas with white light of proper intensity. Wall and carpet areas then reveal their true colors.

Experience has shown that greatly increased carpet life on stairs results when a nosing radius of ½ to ¾ in. is used. Theater architects prefer, for the most part, a ¾-in. radius. The Committee's suggestion for stair lining, in addition to the radii outlined above, is a ¼-in. layer of sponge rubber across the tread and over the nosing. The sponge rubber should end at a point just under the nosing, against the riser. Over the sponge rubber a layer of regular 40-oz lining should be used. The nailing strips should be countersunk, if possible, on the flat tread where the riser begins. The 90-degree pulling force against the carpet nails has proved more satisfactory than that against a wood corner strip.

Aisles should be countersunk approximately ⅝ in. in all new construction. This allows a 54-oz lining plus a good grade of carpeting to fall almost flush with the floor. Here again, nailing strips should be countersunk in the depressed aisle when the concrete is poured. A beveled edge on the strip, with the widest edge buried in the concrete, will prevent pull-out. Plywood strips have been found best because of their greater retention of the carpet nail and because the resins in plywood resist termite infestation.

Determination of quality in purchasing carpet can be confusing to the uninitiated. Experts determine quality by the density of wool per cubic inch. The durability of any carpet varies as the square of density and pile height. Competing samples of carpet should be compared as to pitch, pile height and wire count. These terms are explained in the publications offered. A very important factor in durability is the blending of wool yarns. The larger the proportion of coarse, long staple wool used in a blend of yarn, the greater the durability. Since blends of yarn cannot be specified, the purchaser in this instance can depend only on the reputation of a manufacturer as well as the past performance of his product.

"On location" cleaning is discussed in *Carpets and Their Maintenance*, described above. Careful use of this information will indicate the safest and best cleaning methods available. Particular attention should be paid Part II of this booklet.

The Theater Engineering Committee sincerely hopes that this report of the Theater Carpeting Subcommittee will find acceptance with interested members of the Society and with theater owners and operators everywhere, and that the publications offered herewith will fill a need of long standing. A package of these two publications is available from the Society at $3.00, plus $0.25 for handling and mailing.

American Documentation Institute

Among the organizations with which the Society co-operates, one of truly fundamental importance but little known in our field, is the American Documentation Institute which is now over ten years of age. Its objectives are promotion and development of documentation in scholarly and scientific fields. This rather inclusive statement of aims is reviewed at length in the first issue of *American Documentation*, the Institute's new Quarterly publication, by its editor Dr. Vernon D. Tate, who is better known to the world of science as Director of Libraries at the Massachusetts Institute of Technology. Directors of engineering, research workers and technical librarians who are concerned with scientific reference matters would do well to look into the work of the Institute, paying particular attention to its two publications *American Documentation* and its *Catalog of Auxiliary Publications*, listing documents deposited with the Institute and available on either microfilm or photo copy.

The Winter 1950 (January) issue of *American Documentation* is Vol. 1, No. 1, 58 pp., 8 × 10½ in. in size. Succeeding issues will have a minimum of 48 pp., and are scheduled to contain advertising. Typographically and in content, it is a very creditable job. Its aims, aligned with those of the Institute, are:

"To serve as an impartial clearing house for information about documentation from any source; for the publication of original research in the field; for reporting investigations of new mechanisms, techniques or devices for documentation and their applications; to assist in the development and adoption of basic standards; to provide bibliographic and other control of the literature; to serve as an effective medium for national and international co-operation and exchange in documentation; to stimulate and discuss new ideas and approaches to existing or future problems; for the publication of material originated by the American Documentation Institute.

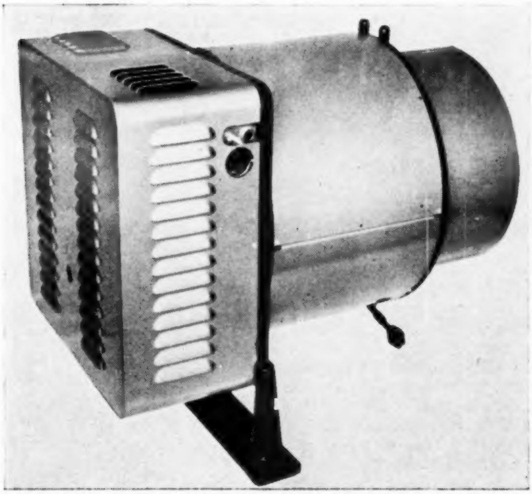
In content *American Documentation* will follow this general outline. It will not duplicate the work of the *Review of Documentation;* it will not follow too closely in the footsteps of its ancestor, the *Juornal of Documentary Reproduction*. Instead, the field of interest has been substantially broadened and particular attention will be devoted to urgent problems in documentation encountered by those engaged in creating, handling, storing and using documents, together with advances in technology. Also covered are microfilm, microprint, microcards, sheet microfilm, photographic technology generally, the new graphic arts including photo-composing machines, Xerography and myriad processes of documentary reproduction, punched cards, digital computers, rapid selectors and facsimile machines. Ultrafax and many other developments all have a place. Approaches to the organization of information, classification systems, semantics and the logic of communication are important. Documentary aspects of graphic portrayal through motion and still pictures, television and the recording and use of sound offer important fields for emphasis. Finally, there are physical and philosophical considerations as yet only dimly perceived that may alter much present thinking; Cybernetics is such a concept.

Annual subscription rate is $5.00 and inquiries concerning subscriptions should be addressed to the American Documentation Institute, 1719 N. Street, N.W., Washington 6, D.C.

Communications regarding manuscripts or other editorial matters should be directed to Dr. Vernon D. Tate, Massachusetts Institute of Technology, Cambridge 39, Mass.

New Products

Further information concerning the material described below can be obtained by writing direct to the manufacturers. As in the case of technical papers, publications of these news items does not constitute endorsement of the manufacturer's statements nor of his products.



Reeves Videon Projection Television has been announced by Century Projector Corp., 729 Seventh Ave., New York 19. Manufactured by the Reeves Soundcraft Corp., the installation consists of the optical barrel assembly, the driver unit, 20-w audio amplifier, remote control unit, screen, screen frame and speaker cabinet, with all connecting cables supplied.

Picture sizes range from 3 × 4 ft, where ambient light is moderate, up to 6 × 8 ft where theater darkness prevails. Remote tuning can be effected up to 100 ft from the screen. Two speakers and cabinets are used with the 6 × 8 ft screen.

The optics of the Videon-Schmitt lens barrel assembly (shown above) are reported engineered for minimum distortion and aberration, with the 14-in. reflector affording minimum loss in light value. The lens barrel can be suspended from the ceiling for front projection or mounted on a shelf for rear projection.

SMPTE Officers and Committees: The roster of Society Officers is given in this issue, pp. 635–37. The Committee Chairmen and Members were shown in the April JOURNAL, pp. 515–22; changes in this listing will be shown in the September JOURNAL.

Letter to the Editor

In "Color Cinematography in the Mines" by M. Charles Linko, in the February, 1950, JOURNAL, there should have been a credit line showing Mode-Art Pictures, Inc., Pittsburgh, Pa., in whose employ M. Charles Linko was at the time he shot the picture outlined in the article.

J. L. BAKER, President
Mode-Art Pictures, Inc.
1020 Forbes St., Pittsburgh 19

Employment Service

POSITIONS WANTED

With 35-Mm Production Unit: Young veteran desires to learn motion picture production. Will work in any capacity. Single, 23, with 8 yr theater experience, all phases; mgr small house 3 yr; 2 yr A.M.P.S. projectionist supervisor; grad. AAF Photo School and Motion Picture Inst. production course. Have private library of over 200 film books; serious student of films since 15. Currently employed; detailed letter and refs readily supplied; salary no object. John P. Lowe, 265 State St., Northampton, Mass.

Producer-Director-Editor: 10 yr with major film producers. Thorough knowledge and experience script-to-screen production technique: directing, photography, editing, laboratory problems, sound recording, 35- and 16-mm, b & w. Specialist in research and production of educational and documentary films; small budget commercial and TV films. Long experience in newsreels. Desire greater production possibilities, go anywhere. Member SMPTE, top refs. E. J. Mauthner, P. O. Box 231, Cathedral Sta., New York 25.

Mechanical-Electronic Engineer: B.S. degree in Mechanical Engineering; extensive design, mfg. experience, standard and drive-in theater picture and sound equipment; experience as engineering assistant to top management exec. corp. in radio TV. Write A. Kent Boyd, 3308 Liberty St., Austin, Texas.

In Manufacturing: Broad experience in developing, improving and producing of home movie cameras and projectors. Good technical background. Desire position with mfr. Earle F. Orr, 345 Fellsway West, Medford, Mass.

On-the-Job G.I. Bill Training: Ambitious young man to be member of camera crew; grad. U.S. Army Signal Corps Schl.; experienced with Cine Spec., 70DA, Eyemo, Wall and Mitchell cameras; studied editing, art directing and cinematic effects at U.S.C.; married, non-drinker, serious; man for small studio TV work. P.O. Box 524, Alhambra, Calif.

TV and Motion Picture Production Supervisor: 18 yr of unusually complete and varied experience in production of films for theatrical, educational, commercial and TV fields. Heavy technical background in animation, special effects, optical printing, stop-motion, as well as live action. Installed five animation and special effects departments now in operation. Chief cinematographer on U.S. Govt. training films. Experience covers Technicolor, b & w, 35- and 16-mm. Good laboratory background. Would like executive liaison position to supervise production, where creative ability and knowledge of lesser-known techniques could be utilized. Will travel anywhere within U.S. Member of SMPTE for 15 yr. More detailed résumé and references supplied on request. Ernest M. Pittaro, 1930 Grand Concourse, Bronx 57, New York.

Good Insurance

It is good insurance for you and your company to keep posted on developments in your own field. Careful attention to convention programs and committee reports, plus intelligent study of the *Journal*, is definitely in order for it may reveal some gaps in your planning for tomorrow.

New color processes, television or the trends in high-speed photography and in sound recording may have an important influence on your future—so put it to work. Both you and the Society will benefit.

Your Society is better equipped than ever before to help you and your associates and is anxious to have new members join. Many believe it unethical to request membership and are just waiting to be asked. Invite them now. A membership application form appears as the last page of the 1950 Membership Directory and the Constitution and Bylaws which define the Society's fields of interest appear in this issue of the *Journal*. The prospective member should read them carefully, and send his application to Society Headquarters:

Society of Motion Picture and Television Engineers
342 Madison Avenue, New York 17

Sustaining Members

OF THE

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

Altec Companies
Ansco Corporation
Audio Productions, Inc.
Bausch & Lomb Optical Co.
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Bijou Amusement Co.
Blumenfeld Theaters
J. E. Brulatour, Inc.
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Burnett-Timken Research Laboratories
Byron, Inc.
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Cinecolor Corp.
Cineffects, Inc.
Geo. W. Colburn Laboratory, Inc.
Consolidated Film Industries, Inc.
Helene Curtis Industries, Inc.
  Natco Division
DeLuxe Laboratories, Inc.
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  Ampro Corp.
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  The Herlner Electric Co.
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Interstate Circuit, Inc.
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Mitchell Camera Corp.
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Motiograph, Inc.
Motion Picture Association of America, Inc.
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  Columbia Pictures Corp.
  Loew's, Inc.
  Paramount Pictures, Inc.
  Republic Picture Corp.
  RKO-Radio Pictures, Inc.
  Twentieth Century-Fox Film Corporation
  Warner Brothers Pictures
Movielab Film Laboratories, Inc.
National Carbon
National Cine Equipment, Inc.
National Screen Service Corp.
National Theaters Amusement Co., Inc.
Neighborhood Theatre, Inc.
Producers Service Co.
Projection Optics Co., Inc.
Prudential Circuit
Radio Corporation of America, RCA Victor Division
Reeves Sound Studios, Inc.
SRT Television Studios
Technicolor Motion Picture Corp.
Terrytoons, Inc.
Theatre Holding Corp., Ltd.
Titra Film Laboratories, Inc.
United Amusement Corp., Ltd.
Universal Pictures Co.
Westinghouse Electric Corp.
Westrex Corp.
Wilding Picture Productions, Inc.